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Sky and TELESCOPE

In This Issue:

Autumn Skies

Clouded Out

Notes on the Nature of Light

Eclipse Saga—II

Stars for October

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Vol. IV, No. 12
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Whole Number 48
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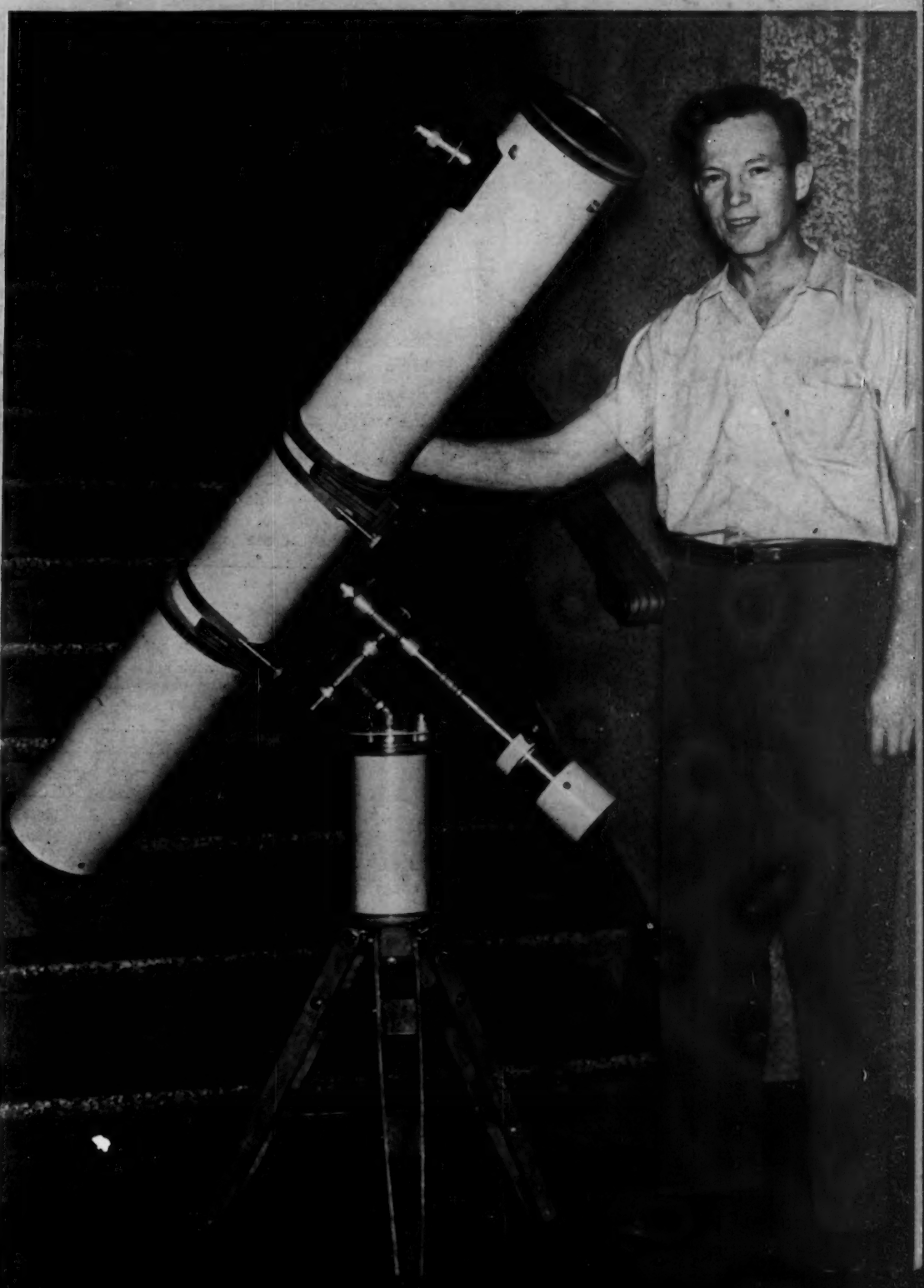

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Sky and TELESCOPE

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The Editors Note

A NOTABLE CONTRIBUTION to the general advance of astronomy will be a feature of certain future meetings of the American Astronomical Society. Already funds have been received toward the establishment of the Henry Norris Russell lectureship.

For some time plans have been under discussion to honor Princeton's famous astronomer on the completion of 40 years on the faculty of that university. At a recent meeting of the council of the American Astronomical Society, the plan for a permanent lectureship in his name was approved, and a committee was selected to raise the necessary principal to maintain a lectureship of international caliber and significance.

No one merits the distinction of this enterprise more than Professor Russell, past president of the American Astronomical Society, of the American Philosophical Society, of the American Association for the Advancement of Science. He is one of the most distinguished of the world's scientists and dean of living astronomers. He has explored many fields, both in astronomy proper and along its borders. Serious astronomical workers have found his expert advice always easily available.

Amateurs have come to know the book of which he is the co-author, **Astronomy**, by Russell, Dugan and Stewart, as a kind of astronomical bible. As this is written, Professor Russell is busily engaged in a complete revision of this essential two-volume text which has no equal in astronomical publications. His monthly articles which appeared until recently in **Scientific American** were without peer in bringing to the amateur astronomer and science hobbyist complete syntheses of current advances in astronomy and related sciences.

The lectureship fund, to which both amateur and professional astronomers and other persons with an interest in the progress of science are invited to contribute, should be the means whereby a high point in astronomy is reached during each year, or as often as the lecture is presented. The lecturer may sometimes be chosen from beyond the bounds of the United States. Publication of the lecture will provide a reference of considerable importance to teachers and students of astronomy.

The opportunity to share in the establishment of the Russell lecture is one which many of our readers and their astronomical societies may welcome. Contributors should communicate with the secretary of the American Astronomical Society, care of Harvard College Observatory, Cambridge 38, Mass.

VOL. IV, No. 12
Whole Number 48

CONTENTS

OCTOBER, 1945

COVER: Allyn J. Thompson and his 6-inch, f/9 reflecting telescope, fashioned exactly in accordance with the instructions in his series of 12 articles on "Making Your Own Telescope," which concludes in this issue. (See page 18.) The instrument weighs 52 pounds and its total cost was about 28 dollars. Photo by Peter A. Leavens.

AUTUMN SKIES—Robert R. Coles 3
CLOUDED OUT 6
NOTES ON THE NATURE OF LIGHT—Part III—Duncan Macdonald 9
ECLIPSE SAGA—II—George V. Plachy 12

Amateur Astronomers 7
Astronomical Anecdotes 8
Books and the Sky 14
Gleanings for A.T.M.s 18
Here and There with Amateurs 21
News Notes 5
Observer's Page 16
Planetarium Notes 20
Stars for October 22

BACK COVER: The Great Nebula in Andromeda, M31, photographed by N. U. Mayall with the Crossley 36-inch reflector at Lick Observatory, exposure, 4½ hours, on November 7, 1937. (See page 3.)

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AUTUMN SKIES

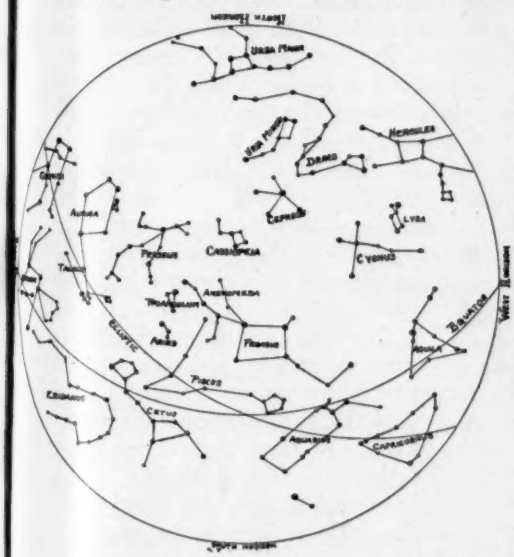
By Robert R. Coles

While the Big Dipper skirts the horizon on autumn evenings, another base for star-gazing, the Great Square of Pegasus, dominates the heavens. Ambitious observers may now study constellations of summer, fall, and winter, as told here and in the Hayden Planetarium this month.

Pegasus, Andromeda, and Pisces are important fall groups.

TO those familiar with the signs of the seasons, each has a charm of its own. Just as the landscape wears a different attire for every season, so the sky picture changes from month to month throughout the year. Although local vagaries of weather may influence the migration times of birds and animals and retard or advance the growth of plant life, the stars can always be relied upon to return on schedule. Thus, for any place on the earth we can predict with certainty just what constellations will appear at any hour.

Autumn in the Northern Hemisphere began this year at 4:50 a.m. (E.S.T.) on September 23rd. Then the sun was at the autumnal equinox, crossing the celestial equator on its journey southward. On that day it rose due east and set due west. Its diurnal path very nearly traced out the great curve of the celestial equator. If the stars had been visible at the time of local apparent noon, when the sun was on the meridian, you would have recognized the constellations that shone in the midnight sky on the first day of spring. Since that first day of spring our planet had swung approximately half way around the sun, and at midnight on September 23rd we saw stars that had been hidden by the noonday sun six months earlier.



A chart of the sky as seen from mid-northern latitudes on October and November evenings.

Just as the seasonal changes on the earth take place gradually, so they do in the sky. In early autumn evenings when the light of day is melting into the full dark of night, many familiar summer stars are rapidly descending the western sky, soon to disappear below the horizon. In those moments of twilight, the bright Arcturus sinks to rest in the northwest; Scorpius fades into the haze on the southwestern horizon. Sagittarius swings low in the southwest and, with his other celestial companions, makes a rapid exit in favor of the stars of autumn.

By 9:00 p.m. standard time October 1st, autumn stars are well into view. For observers located in mid-northern latitudes, the Big Dipper may be seen swinging low across the northern horizon but still to the west of the meridian. Cassiopeia climbs the northeastern sky approaching the meridian. The constellation of Cygnus, the Swan, appears high overhead, just beginning to descend the western half of the sky. The brilliant Vega, in the constellation of Lyra, the Lyre, is also high in the west at that hour. These stars and constellations are common to both summer and autumn.

Just to the east of the meridian, the Great Square of Pegasus, the Winged Horse, rides high above the southern horizon. Actually only three of the four stars of the Great Square belong to the constellation of Pegasus. These are Scheat (Beta Pegasi), in the northwestern corner of the square, Markab (Alpha Pegasi), in the southwestern corner, and Algenib (Gamma Pegasi), which marks the southeastern corner. The northeast corner of this famous quadrilateral is marked by Alpheratz (Alpha Andromedae). It must be admitted that a better-than-average imagination is required to see anything even remotely resembling a horse among the stars in this region of the sky. The old star maps and celestial globes represent the horse upside down with his forefeet projected upward into the heavens. Observers in the Southern Hemisphere, however, see the horse right side up. The outline of the Great Square is much more easily seen and stands as a familiar guidepost among the stars of autumn. This is a constellation of great antiquity, and it is said to have been regarded by the ancient Phoenicians and Egyptians as representing the emblem of a ship.

The stars Alpheratz, Scheat, and Markab, are 2nd magnitude, while Algenib is of the 3rd magnitude. These four stars stand out prominently, so that the Great Square can be easily found even on nights of bright moonlight.

The square serves the practical purpose of locating the equinoctial colure, the hour circle occupied by the sun when it is at the vernal equinox. This is a great circle from the north celestial pole extending just to the east of the star Caph (Beta Cassiopeiae), then south through Alpheratz and slightly to the west of Algenib; then it continues a distance about equal to the height of the Great Square to the place in the sky where the ecliptic crosses the celestial equator and which is occupied by the sun on the first day of spring. This is the point in the sky from which right ascension,

Those interested in combining mythology with constellation study will find useful a star chart such as this. Some of the "watery" part of the sky is shown, including Aquarius, Pisces, Cetus, Capricornus, and the constellation of the Southern Fish, Piscis Austrinus.

one of the important celestial coordinates, is measured.

Associated with Pegasus in mythology and in the sky is the constellation of Andromeda, the Chained Lady. As previously mentioned, the star Alpheratz (Alpha Andromedae) is located in the northeast corner of the Great Square. At 9:00 p.m. on October 1st, the constellation of Andromeda may be found high in the northeastern sky about half way between the horizon and the zenith. A chain of four conspicuous stars, beginning with Alpheratz, presents the main feature of this constellation. This chain of stars extends in a general northeasterly direction and includes, next beyond Alpheratz, a 3rd-magnitude star known as Delta Andromedae, Mirach (Beta Andromedae), and about one and a half times farther away, Almach (Gamma Andromedae).

In the constellation of Andromeda is to be found the great galaxy M31 (see back cover), most distant object that can be seen without the aid of a telescope. This enormous system of stars appears to the unaided eye as a hazy blob of light about seven degrees (or a little more than the angular distance that separates the Pointer stars in the Big Dipper) to the northwest of Mirach. It can be seen best only on clear, moonless nights and then only in a sky that is free from smoke and the artificial glare of cities and towns. When we stop to realize that this object is actually a vast universe of stars beyond the farthest outposts of the Milky Way galaxy, at a distance of 750,000 light-years, we acquire some slight conception of the vast extent of the great cosmos to which we belong. At about midnight, this galaxy is approaching the zenith for observers near 40° north latitude.

At 9:00 p.m. on the first of October, the 1st-magnitude star Capella, in the constellation of Auriga, the Charioteer, is about 10 degrees above the northeastern horizon. At latitude 40° north, this star is very nearly circumpolar; in fact, it is below the horizon for only about five out of the 24 hours. At about 44° N., it becomes a circumpolar star and is above the horizon for the entire 24 hours.

Six zodiacal constellations are to be found roughly marking the path of the ecliptic. Sagittarius is just beginning to descend below the horizon; following it along the ecliptic is Capricornus just to the west of the meridian; Aquarius appears directly south; in the southeast and east is the constellation of Pisces; beyond this in the northeast is Aries, and just on the northeastern horizon is Taurus.

This is a constellation associated with winter, and by midnight it has climbed high enough so that Aldebaran, the bright star marking the right eye of the bull, is about 35 degrees above the eastern horizon. By that time Orion is just appearing in the eastern sky. From then until the light of dawn hides the stars, more and more of the winter constellations appear. Thus we see that if one observes in the east long enough through the night, he may get a preview of the next season's stars.

By midnight, the wide belt of the Milky Way spans the sky from the northeastern to the southwestern horizon, dividing the visible heavens into two nearly equal parts. This will be particularly striking on clear, moonless nights.

For those who this year want to observe the Great Nebula in Andromeda, we suggest that the best results may be expected during the first 10 days or the last week of October. Full moon occurs on the 21st, and its brilliance will render observation of this galaxy difficult.

This full moon of October 21st is popularly known as the hunter's moon, for there will be an interval shorter than normal between the time of moonrise from one night to the next. On the night of October 21st, the moon will rise about 34 minutes later than on the 20th. Moonrise on the 22nd is only 36 minutes later. In view of the average daily retardation of moonrise of 52 minutes, this brings the hunter's moon (and the harvest moon of the preceding month) into the sky earlier in the evening than average.

The changing sky picture is one of the most interesting phases of observational astronomy. The gradual march of the constellations across the sky, with their familiar brilliant stars, varies the background against which the moon and planets are continually changing. To anticipate the return of well-known constellations is one of the first steps in becoming familiar with the geography of the night sky.

NEWS NOTES

By Dorrit Hoffleit

NOVA IN AQUILA

On August 28th, Dr. Nils Tamm, of the Kvistaberg Private Observatory in Bro, Sweden, discovered a 7th-magnitude nova in Aquila. Its position, according to a radiogram from Copenhagen, is at $19^h\ 16^m.0$, $+0°\ 35'$, 1945 co-ordinates. Harvard photographs taken on August 29th and 30th showed its photographic magnitude to be about 7.5, although the radiogram had given this as 8.5. The spectrum, similar to that of Nova Geminorum, indicated that the nova was already then past maximum light phase. According to nova expert Dr. Dean B. McLaughlin, of the University of Michigan Observatory, the star was probably one or 1½ magnitudes fainter than at its maximum.

The Swedish astronomer already has to his credit the discovery of two earlier novae in this same constellation.

INTERESTING ECLIPSING VARIABLES

VW Cygni and AQ Pegasi are eclipsing binary stars with remarkable spectra recently analyzed by Dr. Otto Struve at the McDonald Observatory. So great is their spectroscopic interest that the information at hand concerning their ranges in magnitude and periods of light variation is inadequate—further photometric observations are needed to supplement the spectroscopic data.

In each case, the normal spectrum is that of a white *A*-type star, but with somewhat unusual lines. During the total eclipse, however, the spectrum indicates that the *A* star is being hidden by a later type, probably of class *G* in the case of AQ Pegasi. Emission lines of hydrogen and other elements, apparently arising from a rotating ring of nebulous matter surrounding the *A*-type star, become strong during the total phase. In each case the red component of the emission is suppressed after mid-eclipse, while the violet component becomes strong, indicating that the shell of nebulous matter is small because it is nearly all eclipsed by the late-type star.

VW Cygni has a period of 8.43 days, its total eclipse phase lasting seven hours, its maximum magnitude about 9.7. AQ Pegasi has a period of 5.5 days, eclipse for five hours, and maximum of 10.0, while its minimum brightness is only 12.7. In these and half a dozen other similar stars, Dr. Struve believes we are here undoubtedly concerned with a general property of close binary stars, and the results have an important bearing on the problem of double-star origin.

THE FIRST AND BIGGEST ATOMIC BOMB

In line with the trend among popular science publications to comment on the atomic bomb, we must mention its relation to our field of science. Theoretical astrophysicists talked about one superlatively great atomic bomb (although not by that specific name) long before the war lords even thought of such a thing. It was the peace-loving Abbé Georges Lemaitre, of Belgium, who 15 years ago envisaged the explosion of one giant primordial atom. The breakup of the giant atom produced the widespread debris we observe as the physical universe, including the Milky Way system and all the myriads of other galaxies.

We don't know anything about the detonator, but many lines of evidence indicate that if Lemaitre's theory is correct, his giant atom exploded about two billion years ago, and as a result the universe is still expanding. The red shifts in the spectra of the galaxies may be interpreted to mean that these systems are receding from one another as they would from a center of detonation. The original explosion itself is still in progress: that is why the stars are shining. Atomic energy is being released in the interiors of stars as they transmute elements according to the same principles of physics as are applied in the most modern weapon of warfare.

MAXIMUM OF T PYXIDIS

Early in April, Dr. A. H. Joy, of Mount Wilson Observatory, noted an increased brightness of the recurring nova, T Pyxidis. (See *Sky and Telescope*, May, 1945, page 15, and June, 1945, page 17.) The star was then about the 11th magnitude, but word has now been received from Harvard's station in South Africa that on November 21, 1944, the star was photographed at magnitude 7.1. This is its usual maximum magnitude, and as later plates show a steady decline in brightness, it is evident that the star reached its maximum in the current outburst five months before Dr. Joy's first observation.

RADAR AND THE WEATHER

In peacetime, war-born radar promises to become of importance to the weatherman, for the Air Technical Service Command has released information on a piece of equipment developed at Wright Field and originally used for blind flying. Instead of being trained on landmarks, the 450-pound unit installed in reconnaissance aircraft in the Pacific area scanned the air around it, tracking clouds. Thus, storms could be "seen" approaching at distances of from 100 to 200 miles; such information was reported to airbases at half-hour intervals, aiding planes near the storm area. Ground radar installations were also adapted to provide meteorological data.

PHOTOELECTRIC RECORDING OF METEORS

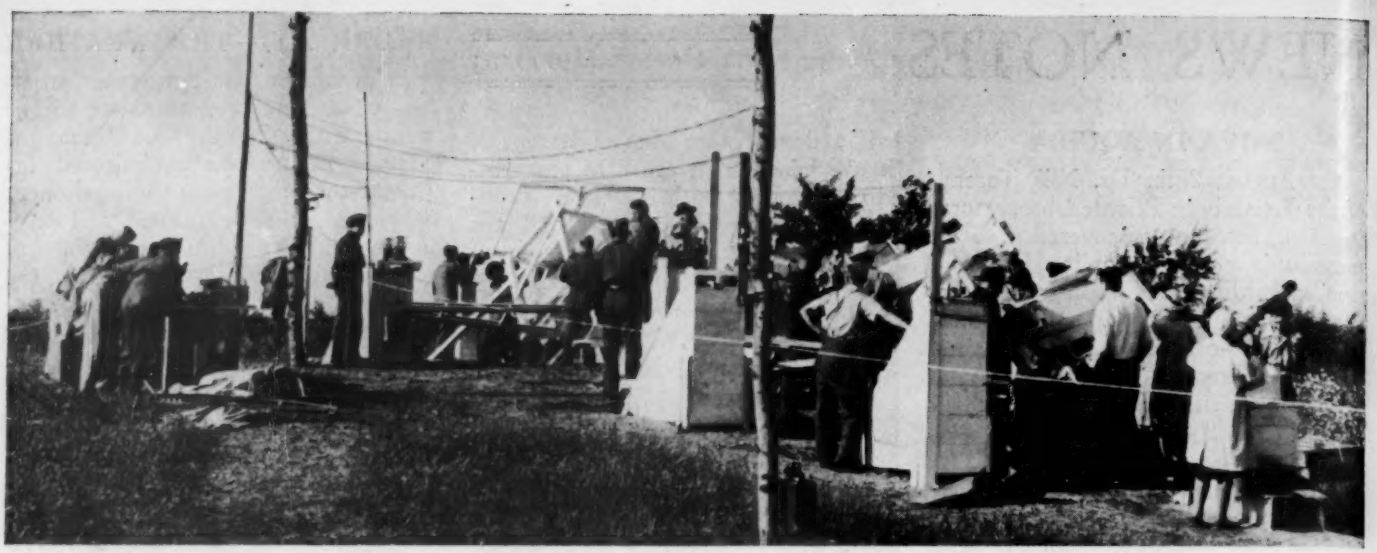
Dr. C. W. Gartlein and an associate at Cornell have devised a photoelectric apparatus which automatically counts meteors and can record their durations and brightnesses. Two photocells in a balanced circuit are aimed at different parts of the sky and, as Science Service reports, "are so synchronized that when one cell intercepts light which is brighter than that being received by the other, a recording pen on the graph is set in motion." Originally designed for aurora work, the apparatus was successfully used during the Perseids.

VERY RED STARS

Dearborn Observatory of Northwestern University is to be congratulated on a massive and important catalogue of faint red stars. In the zone $+13°.5$ to $+40°.5$, 14,539 stars with magnitudes mostly between 8 and 11, some as faint as 13, have been classified as spectral type *K*5 and later, on special red-sensitive plates. This is the second such catalogue published by Dearborn; together they cover nearly one third of the sky.

Late *M*-type stars (*M*5 to *M*8), rich in titanium oxide, can be found on the Dearborn plates to an apparent magnitude of 12.3 and fainter. This represents a distance of 123 light-years for dwarf stars; while giants, if space were transparent, could be seen to 12,000, and supergiants to 53,000 light-years. If such stars were numerous, they should certainly have been found in considerable numbers in the Dearborn survey. Among a total of 22,680 red stars catalogued, only 948 brighter than 10th magnitude and 551 fainter

(*Continued on page* 21)



BREDENBURY: An informal picture of the personnel and instruments, taken during a rehearsal. Comdr. Menzel, at the extreme left, is bending over the timing table where the chronometer, Longines stop watches, and electrical circuits for recording time on the films were located. Left of center is the "calf-crate" mount which carried two large spectrographs, driven by clocks at its left. Down the line are the mounts and clock drives for other photographic and spectrographic equipment. The area surrounding the instruments was roped off for several days prior to eclipse morning. Photo by Cliff Shaw, Yorkton, Sask.

CLOUDED OUT

With this issue we conclude reports of American expeditions at the July 9th eclipse. Other eclipse stories will be found on pages 11, 12, 16, 17, and 21.

FIFTH EXPEDITION. The fifth solar eclipse expedition in 14 years to be sponsored jointly by Brown University and Skyscrapers, Inc. of Rhode Island, was sent to Roblin, Man., under the direction of the writer. Nine persons were included in the party, Dr. and Mrs. Smiley, F. W. Hoffman, Rev. Wm. Fagan, Maribelle Cormack, president of Skyscrapers, and Wilhemina Null, Mary Quirk, Evelyn Lindsay, and Priscilla Biron. Dr. C. H. Gingrich, editor of *Popular Astronomy*, was invited to join us at Roblin.

Two problems were undertaken by the expedition: the precise timing of the four contacts, and the absolute measurement by visual means of the brightness of the outer corona, including the zodiacal light in the vicinity of the sun. Mr. Hoffman used a high-speed motion picture camera and telephoto lens, combined with a neon light flashed regularly by a chronometer which in turn recorded on a chronograph. Individual estimates with stop watches were to have been made in the usual way, with the probable error reduced by sheer numbers. All times were checked against WWV, the radio station of the National Bureau of Standards. Four visual photometers of the latest design were to be used, all dark adapted by special Welsh glasses.

Unfortunately, all four contacts were completely clouded out. The Skyscrapers had insured against such a misfortune and this provided the one cheerful note in an otherwise gloomy day. It is hoped to send an expedition to eastern Brazil on May 20, 1947.

CHARLES H. SMILEY
Ladd Observatory

JOINT PROGRAM. When representatives from Northwestern and Beloit met at Roblin, Man., with quite

BREDENBURY: As this photograph of the scientists and Army engineers was taken the day before the eclipse, the group looks quite cheerful. Standing, holding a dark hat, is Dr. H. D. Smith, of Vancouver; to his left are Dr. G. Herzberg, Saskatoon; Helen S. Federer; Dr. C. S. Beals, Dominion Astrophysical; Capt. E. S. Baily, Royal Canadian Engineers; Lt. Comdr. Donald H. Menzel, leader of the expedition; S. C. Brown, of Toronto. Kneeling, left to right, are the editor, who took the picture, and Mr. and Mrs. J. F. Chappell, of Lick Observatory, expedition photographer and recorder, respectively. Standing behind Mr. Brown is Dr. A. E. Johns, of Hamilton, and at extreme upper right is his son, Dr. Harold E. Johns, of Edmonton.

similar programs for observing the eclipse, it was decided that both groups would profit by a joining of forces. The men involved were T. J. Bartlett, of Dearborn Observatory, and R. M. Cook, of the Northwestern Technological Institute, both of Northwestern University, and R. C. Huffer, of the astronomy department of Beloit College. We were joined by some 15 local volunteers, and by C. F. Graham, of the Burnham Astronomical Society of Chicago.

Our program had three general objectives: to draw the corona, paying particular attention to the faint coronal streamers which are impossible to record fully by photography; to time accurately the four contacts and compare with the predicted times; to make various meteorological observations relating to the shadow of the moon and its effects. Our observing equipment consisted of a theodolite, two sextants, artificial mercury horizon, radio, chronometer, stop watches, several small telescopes, and various lesser pieces. Due to heavy clouds which prevailed from sunrise until roughly two hours after fourth contact, the greater portion of our program was thwarted.

Some of our observers, facing in a direction opposite to the sun, observed the approach of the shadow as it fell in through the clouds and into a very narrow clear stratum a degree or two above the southwest horizon. Overall darkness was not as great as expected during totality. An accurate 5-minute interval record was made of the temperature from 30 minutes before first contact until 18 minutes after last contact. A drop of approximately 1° C. from the established gradient was observed at mid-totality.

T. J. Bartlett and R. M. Cook
Northwestern University
and R. C. Huffer
Beloit College

BREDENBURY: A view of the sunward side of three piers and clock-drive supports. Hinges serving as polar axes were attached to each pier. These hinges carried a large "barn door" on which several instruments were placed; a long arm extending to the westward was lowered on rollers down an inclined platform in the equatorial plane. Each pier had its own clock drive. At the right is the long-focus corona camera (Swarthmore lens) and a shorter camera mounted with it; in the center are two spectrographs; and at the left are two more corona cameras; in addition, all mountings carried auxiliary still and motion-picture equipment. Photo by J. F. Chappell.

Amateur Astronomers

A.A.A. FALL CLASSES

Announcement of the program for the fall season is made by the Amateur Astronomers Association of New York, classes to begin on October 8th. Courses will be conducted in general science, physics review, the planets, elementary astronomy, mathematics, a seminar in astrophysics, and telescope mirror making.

In addition to these formal classes, public observation meetings outdoors are scheduled for the third Wednesday of each month, beginning October 17th. Further information may be had from the secretary of the association, George V. Plachy, Amateur Astronomers Association, American Museum of Natural History, New York 24, N.Y.

THIS MONTH'S LECTURES

Chicago: "Popularizing Astronomy" is the subject of Carl H. Gamble's talk before the Burnham Astronomical Society, Tuesday, October 9th, at 8:00 p.m. A general discussion by members on the October evening sky will precede the lecture. The meeting place is the Chicago Academy of Sciences auditorium.

Cincinnati: Leslie C. Peltier will speak concerning comets and comet discovery to the Cincinnati Astronomical Association on Friday, October 12th. The meeting is at the Cincinnati Observatory at 8:00 p.m.

Detroit: Members and guests of the Astronomical Society will hear Professor W. Carl Rufus, of the University of Michigan, lecture on "Other Planetary Systems," including discussion of new ideas regarding the evolution of the solar system, at the Sunday, October 14th meeting, held at Wayne University at 3 o'clock.

Indianapolis: "The History of the Astronomical Society" will be discussed by Samuel Waters at the October 7th meeting of the Indiana group. The meeting is on Sunday at 2:15 p.m., in Odeon Hall.

New York: "A Report on the A.A.A. Eclipse Expedition" to Butte, Mont., with several members speaking, will be presented at the October 3rd meeting of the Amateur Astronomers Association. The meeting is to be held in the Roosevelt Memorial building of the American Museum of Natural History at 8:00 p.m.

Washington, D.C.: At the meeting of the National Capital Amateur Astronomers Association on October 6th, 8:00 p.m., Dr. Paul S. Watson will take "A Voyage Through Space." The meeting is at the National Museum.

BURNHAM SUMMER ACTIVITIES

While no regular meetings were scheduled for the summer months, the Burnham Astronomical Society reports that several special events were on their summer program. The first of these was an observation party and barbecue, at Mt. Prospect, Ill., attended by some 38 or 40 persons, with eight telescopes in use.

On August 15th, an observation party, with about 10 telescopes furnished by B.A.S. members, was announced, for the pleasure and entertainment of the veterans in the Vaughan General Hospital, Hines, Ill. (Ed. Note: Perhaps other amateur groups will investigate the possibility of offering a similar program in their own localities — surely a worthwhile undertaking.)

ASTRONOMICAL ANECDOTES

"DID A COMET STRIKE AMERICA?"

IN A WAY, I'm hoist on my own petard, for as recently as January, 1945, in this department, I said, "We show ourselves much too timid in permitting incorrect notions to prevail, and even to become enlarged, in the public mind. We only smile and say, 'Tsk, tsk,' as we read some colossal nonsense published about astronomy, when we should, with full recognition of our responsibilities to science, put ourselves on record with its author that we don't approve of his particular brand of pseudo-interpretation." I bow my head with shame, because a spectacular and largely untrue article, published in a national weekly of several million circulation, in September, 1944, has now been reprinted in another national magazine of tremendous circulation, in June, 1945. I saw the original article in an advance copy; it was too late then to stop it, and I let too much time pass and failed to write the protest I have so vigorously championed. Now the nonsense is popping up on all sides, to small credit of astronomers, who have been put in the light of denying what the author says is indisputably true.

The article, originally titled "When the Comet Struck," was pepped up a little in the later version by the new title, "When the Comet Struck America." The author has been very roundabout in his approach, for he says that there are many who deny his theories altogether, and they include pretty solid scientists; there are others, he says, who believe the tale, and then he says that he will listen only to the latter. If he can name three or more who, having seen the evidence and read even a little of the appropriate literature, believe his interpretation, he may be justified, but I doubt his ability to do it. Certainly, with both my ears to the ground as I try to keep abreast of current fact and opinion in things astronomical, I had the impression that what the author tells as true was as dead as a dodo.

The question is this: Are the so-called Carolina bays of meteoritic origin? Let's forget the article here mentioned, and concentrate on one by a scientist, who gives all sides of the story. He is the late Professor Douglas Johnson, of the department of geology, Columbia University; in the January, 1944, issue of the *American Scientist*, quarterly of the Society of the Sigma Xi, his article on "Mysterious Craters of the Carolina Coast" bears the subtitle, "A Study in Methods of Research." It is a clever thing, illustrating vividly how possession of only part of a story can lead not to part of the truth, but more likely to all of an untruth.

"The flat coastal plain of South Carolina and portions of adjacent states is pitted with a vast number of curious oval craters. These depressions vary in longest diameter from a few hundred yards to two or three miles, are partially surrounded by rims of fine-grained sand, and usually have marshes or peat bogs on their floors. . . . To the natives the oval craters are known as 'bays,' a name possibly derived from the bay tree frequently found growing in the depressions." To this opening paragraph of Professor Johnson, a friend of a friend of mine adds that "savannah" is the name for the formations, in Georgia.

Professor Johnson divides his article into several sections, the first of which is "Observation and Inference." His materials are these: Each bay or crater is oval, the longest axes of the depressions are almost if not quite completely parallel and trend uniformly from northwest to southeast; there are tens of thousands of craters on the Carolina coastal plain; the ridge of sand is most strongly developed about the southeasterly half of each crater. By induction, one can conclude that it seems that these craters were formed by the impact of many thousands of meteoritic bodies which came streaming across the country from northwest to southeast. As a deductive check on the inductive method of arriving at this conclusion, Professor Johnson examines the area of most abundant meteorite finds and discovers that an oval area including most of the craters overlaps the region of most abundant meteorites; further, he finds that magnetometer checks at the southeastern rims of the craters reveal magnetic "highs," due to the influence of iron in these regions, as though many of the meteorites may be buried there.

The conclusion is, "On the face of the record I have made out an excellent case for my hypothesis. If the conclusions are published they will be incorporated into textbooks of geology and astronomy. But I hesitate. . . . [The scientist] knows that methods of research can be seductive as well as deductive or inductive. . . ."

Now this is as far as the reading and reasoning of the popular writer took him, in the misleading article now given circulation to millions of homes. What he missed is the whole story, and next month we'll continue along this path. R.K.M.

NEW HAYDEN PLANETARIUM DIRECTOR APPOINTED

ON THE 1st of September, Lt. Comdr. Gordon A. Atwater became chairman and curator of the department of astronomy and the Hayden Planetarium of the American Museum of Natural History, following his release from active duty. Since the death of the former director, William H. Barton, Jr., in July, 1944, Miss Marian Lockwood, associate curator, has been acting curator.

Interested in astronomy and navigation since his youth, when he and his brother designed and built sailboats on Lake Erie, Comdr. Atwater has had charge of training naval officers in navigation at the U.S. Naval Training School (Advanced) at Fort Schuyler, in the Bronx, New York City, which later became the U.S.N.R. Midshipmen School. All the navigation training facilities there, and the building in which instruction in nautical astronomy was given, were designed by Comdr. Atwater.

In the past, the new director has co-operated with Hayden Planetarium officials in planning regular and special courses and lectures for naval personnel visiting the planetarium. He suggested the earth device which has been added to the Copernican instrument lecture to explain the determination of time. He proposes to expand the planetarium's program for navigation training and piloting classes, and to continue co-operation wth the various armed services. As a member of the Westchester unit of the U. S. Power Squadron, Comdr. Atwater is expected to devise programs for yacht clubs and power squadron groups.

For 16 years before joining the Navy in June, 1942, he was a salesman, also handling credit and purchasing, for a lumber company. His college training, at Purdue University, was in engineering. To turn his full-time efforts to popular astronomy is a somewhat unexpected change, and the New York *Herald-Tribune* quotes him as saying that the post of curator "was the last thing I ever visualized myself in."

Notes on the Nature of Light

By Duncan Macdonald, *Boston University*

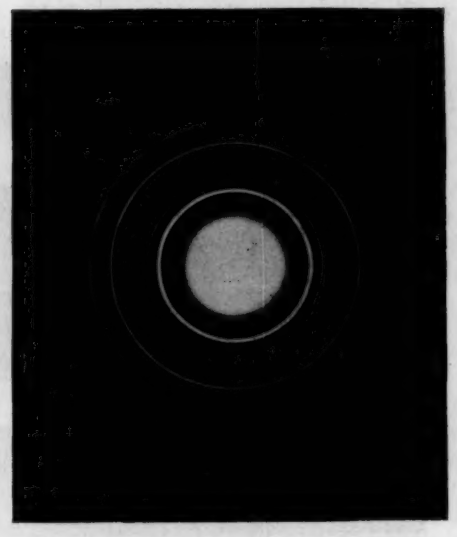
Part III

IN 1922, L. de Broglie pointed out the similarity between the laws of optics and of mechanics. He found that light corpuscles behaved as material particles of infinitely small mass. Expanding this thought, de Broglie suggested that all material particles have wave lengths associated with them, the more massive the particle the shorter the wave length. Several verifications of this similarity between matter and light have been established. The diffraction of electrons indicates that these ultimate particles of the material universe behave at times as waves.

The weighing of high-velocity electrons has shown that their masses increase with their velocities, a change predicted by relativity theory. To speed up an electron, it must receive energy; when it slows down it must give up energy. The conclusion is that the increase in an electron's mass with velocity increase is due to the additional energy that the electron has received. In other words, the energy manifests itself as mass. Indeed, as we have recently seen in the atomic bomb, the conversion of a small amount of mass into radiant energy is a true and powerful thing.

This conversion of a small portion of the mass of an atom (known as the packing fraction) into energy has been accepted for several years by astronomers as the fundamental energy source of the universe, the fuel of the stars (see The SKY, December, 1940). In the case of the atomic bomb the sudden conversion of mass results in the radiation of tremendous electromagnetic energy. This sudden creation of light is evident in the photographs which show the explosion of the bomb. For a brief time the whole volume of space where the bomb explodes is as hot and shines as brightly as the surface, and perhaps the interior, of a hot blue star.

The formula relating mass and energy is $E = mc^2$, where E is the energy that can be obtained from a mass m, and the ratio of these is c^2, the *velocity of light squared*. Suppose a United States nickel coin, weighing approximately five grams, were completely converted to radiant energy. $E = (5)\ (3 \times 10^{10})^2 = 45 \times 10^{20}$ ergs. This is 45×10^{13} joules, and a watt is one joule per second. Thus, we could obtain energy enough to operate a 100-watt light bulb for about 140,000 years. At a cost of five cents per kilowatt hour for the usual electric power, this would run to $6,000,000.



Proof of the wave nature of electrons. This typical diffraction pattern is caused when an electron beam from a pinhole source is passed through a film of aluminum about 100 angstroms thick. Photo by L. H. Germer, Bell Telephone Laboratories.

We have just applied the second of the important universal laws, the first of which is the law of probability, discussed in Part II. This second law is the conservation of the total material content of the universe, by which we mean the sum of the energy and mass. In elementary physics, we have always separated this into two laws, the conservation of energy and the conservation of mass, but today we realize that it is the combined mass and energy which is conserved.

There is one other universal law that should be mentioned: the second law of thermodynamics. This tells us that the flow of energy is away from the energy concentrations (hot spots) toward the regions of lower energy (cold spots), for example, from a star to outer space.

Thus, perhaps, we now have in broad terms a simplified picture of our physical universe—it consists only of radiant energy obeying the three general laws.

Now let us turn to the role played by light in problems of the macrocosmos. Distant galaxies appear redder than those nearer to us; the linear relationship between the degree of reddening and the distance of a galaxy is the observational basis for the theory of the expanding universe.

Suppose you are sitting on the bank of a uniformly flowing river. A boy standing some distance upstream is throwing sticks in the river, one stick a second, and they pass you at this frequency. If the boy starts to walk downstream (relative approach toward you) still tossing in one stick a second, the frequency with which the sticks pass you is greater than one a second. Conversely, if he walks upstream (relative recession) the sticks will pass at greater intervals. In these cases, the frequency emitted at the source is unchanged, but the frequency at the receiver depends upon the relative motion of the source and the receiver. The boy may remain stationary while you move toward or away from him and the effect is nearly the same.

In a similar manner, in the case of light waves, relative approach increases the frequency and the light appears bluer than its actual color at the source; relative recession decreases the frequency and reddens the light. This *Doppler effect* changes all wave lengths—the entire spectrum is shifted—but it is most convenient to measure it as a shift in the positions of the dark or bright lines usually found in the spectra of stars, nebulae, and galaxies.

Except for those in our local group, not over a million light-years away, the spectra of all galaxies show a red shift. At five million light-years, the recession is 500 miles a second; at 25 million, it is 2,500 miles a second; galaxies 250 million light-years distant are receding at nearly one seventh the speed of light!

After an explosion, those particles having the greatest initial velocities travel farthest fastest; their distance from the source is proportional to their speeds and the time elapsed since the explosion. Thus, the galaxies seem to be part of an exploding and expanding universe, but Edwin Hubble, of Mount Wilson Observatory, has pointed out that the apparent red shift may be due to a now unknown principle of physics, observable only where vast distances are concerned.

A partial explanation is offered by his suggestion that light gets "tired" as it traverses intergalactic regions. As

its energy decreases, its wave length increases, for red light has less energy than violet light (see Part II). This would account for the observed effect in which the total luminosity of a galaxy appears to be less than expected for its size and distance. In the case of the expanding universe, this effect is to be expected as a result of the apparent reddening of the light by the Doppler shift.

These problems are tied up with the observational procedure whereby we probe space with large telescopes, measuring the magnitudes, distances, sizes of nearby galaxies and applying statistical assumptions to obtain the same information concerning the distant systems. Hubble's study of the distribution of galaxies in space appears to indicate a non-velocity red shift, thereby implying a static universe. His observations, however, are critical only at the limit of the 100-inch telescope (500 million light-years) and need to be pushed to a greater depth in space. There the observable differences in the two interpretations of the red shift should be greater, and the 200-inch telescope may bring the answer. At present, because of our failure to find any physical cause for the red shift other than recession, we tend to hold to the idea of an expanding universe.

Einstein and de Sitter have developed idealized cosmogonical models of the universe. Einstein started by assuming that the initial contents of the universe determined its size—his result has been termed a universe with matter but no motion. Taking in more degrees of freedom in initial conditions, de Sitter arrived at a universe often said to have motion without matter. Actually, in this case all material was swept into the remote corners of space—de Sitter's is the only model which predicts a red shift that increases with distance from the observer. These two models give the extremes of the existing matter-motion conditions; the true picture probably lies somewhere between them.

In his theory of relativity, Einstein suggested that the geometry of space is distorted by the presence of matter. Light rays traveling on the three-dimensional surface of space (as we travel on the two-dimensional surface of the earth) would then appear deflected when passing near matter. The well-known deflection of light rays from stars near the limb of the sun at a total eclipse seems to verify this prediction.

Space, a three-dimensional surface imbedded in a hyper-dimensional space, can have several "shapes," all affected by the presence of matter. However, it is generally accepted that space curves back on itself as does the earth's surface—a finite, yet unbounded universe. Just as one may circumnavigate the earth by proceeding in one direction, so light, traveling on our three-dimensional surface, may circumnavigate the universe and arrive back where it started, unless there is some barrier.

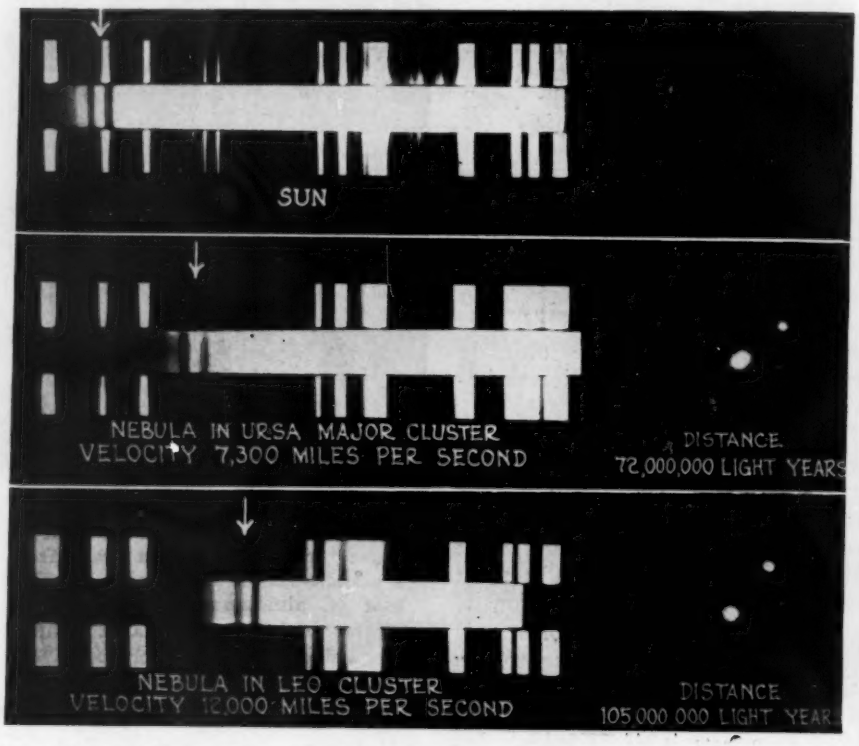
There may be such a barrier. Red shifts observed already approach one quarter the speed of light. If, at the limit, the universe is expanding with the speed of light, a light ray could never catch up with the distant galaxies, and hence could not circumnavigate the universe. The model of de Sitter also interposes a barrier, a slowing down of the rate of flow of time as the distance increases, so that at diametrically opposite points on our space surface, where time becomes stationary, things do not move. Again, observations to greater depths of space are required.

As space is curved, the definition that a physical straight line is the shortest distance between two points becomes inadequate, for we may travel the shortest distance on an arc of our space surface. We should define the straight line as the path of a light ray in matterless space.

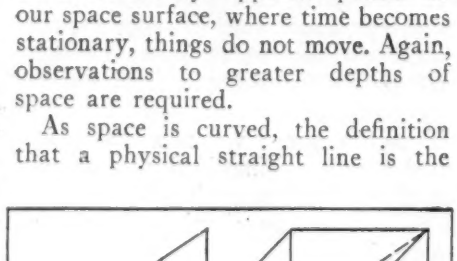
Einstein, taking into consideration the result of the Michelson-Morley experiment, postulated that the velocity of light in free space as measured by any observer, regardless of his motion toward or away from the source, would be constant, and this constant would be the same for all observers. Einstein's thought was that heretofore physics had formulated an idealized system not based on observation, but on the manner in which we should expect things to behave. If there were departures in our measures, they were corrected for our idealized observer, and were therefore not true representations of the way things actually happened. The result of the Michelson-Morley experiment showed that we would find the velocity of light to be a constant regardless of our motion. Why not take this as the true picture?

The result of every test of the predictions of relativity has confirmed the theory. Because of its importance, let us consider the role the velocity of light plays in relativity theory:

By means of the simple right triangle in the diagram, the space-inter-



The relative positions of the H and K lines of calcium (marked by the arrows) show the striking red shift in the spectra of distant galaxies. This is the observational basis for the expanding universe theory. The bright-line spectra are from a laboratory source.



val s between two points can be determined by the expression $s^2 = x^2 + y^2$, or in the case of the cube:

$$s^2 = x^2 + y^2 + z^2 \qquad (1)$$

Velocity is distance divided by time: $v = s/t$ or

$$v^2 = (x^2 + y^2 + z^2)/t^2.$$

If we consider that there is a fundamental velocity, c, the velocity of light, we can rewrite the above expression in terms of the fundamental velocity as

$$c^2t^2 = x^2 + y^2 + z^2, \text{ or}$$

$$0 = x^2 + y^2 + z^2 - c^2t^2. \qquad (2)$$

If this fundamental velocity is taken as unity, the expression becomes

$$0 = x^2 + y^2 + z^2 - t^2$$

which is more generally written

$$s^2 = x^2 + y^2 + z^2 - t^2. \qquad (3)$$

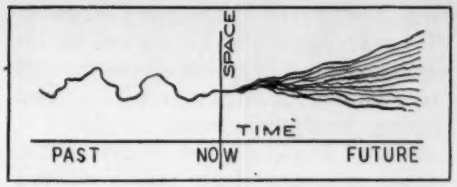
The interval in space and time is s, and, as we see, is zero for flat space-time (the analogy is plane Euclidean geometry). It is more correctly written for very small intervals of any kind of space-time as

$$ds^2 = dx^2 + dy^2 + dz^2 - dt^2. \qquad (4)$$

Notice how similar (3) is to the three-dimensional interval (1), with the negative sign having the unique ability to transform time squared into space squared.

The velocity of light has therefore been made fundamental in determining the interval between points in space-time. This is not an artificial interval. We are beings of four dimensions, for we live in space and time and we picture the interval between events as an interval of space, as an interval of time, or an interval of space and time combined. The fundamental point is that in relativity the interval will be the same for all observers regardless of their position or motion. This is not so unless we use formula (3), in which the velocity of light is unity, to express the interval.

Our awareness of the passage of time is dependent upon the rate at which light signals are received by our minds—the velocity of light is the limiting rate of our conscious perception. This is most easily shown by imagining the result if we could react at a faster rate. Then our lives would be filled with gaps, while we waited for the next light signal to continue our reactions; otherwise we would view the future, but, of course, the light bringing the future would not yet have arrived. True enough, we might not be conscious of our lapses, but we could detect them in other people by close observation. On the other hand, if we reacted at a slower rate we would never catch up to the present. This might prove more difficult to detect.



As an interesting sidelight on this point, I should mention a book by Dunne, entitled *An Experiment With Time*, wherein he attempts to show that the subconscious mind can perceive at a rate greater than that of the velocity of light. If so, this means that this mind can see into the future. The writer leans away from Dunne's evidence, but the speculation it produces is worth considering.

A graph of space and time for our world-track is a picture somewhat like that of the accompanying diagram. Our past is well-defined, the future hazy on the basis of the uncertainty principle. You can see in this picture the true four-dimensionalness of us, as we exist in a three-dimensional space that flows through time. The *now* axis, which might more correctly be termed present time, moves toward the right with the velocity of light, and, as it slides along, the uncertainty spread in the future narrows down to meet it. Dunne tries to show that the subconscious mind can stand off, as we are now doing, and peer into the future of our space-time diagram. It can do this because it travels faster than the velocity of light, getting ahead of the *now* axis and into the future. The conscious mind, on the other hand, travels with the *now* axis and thus keeps up only with the present.

There is one other important role played by this most fundamental velocity constant of nature, that of selection of the inhabitants of the universe. No physical thing can ever travel faster than the velocity of light. If such should happen, the object would depart from our universe.

An experiment has been suggested that would seemingly violate this rule. Take a most powerful searchlight and rotate it about an axis once a second. The end of this beam at, say, the distance of the orbit of Neptune would then be traveling in a circle with a velocity greater than that of light. Although an observer on Neptune would see one flash a second, it is clear that no physical object is traversing the circumference at this rate. It is, perhaps, easier to picture the case of a rotating lawn sprinkler. Each drop of water travels out along a radius, as does each photon from the searchlight. The rate of rotation determines merely the rate of wetting the circumference. The water drops (photons) travel at right angles to the circumference and the rule is not violated.

Imagine the chaos that would result if a velocity greater than that of light were the limiting velocity in our universe: objects leaving before they arrived—one object existing at several points at the same time. The situation is well covered by the following, author unknown:

There was a young lady named Bright,
Whose speed was faster than light;
She eloped one day
In a relative way,
And returned on the previous night.

THE END

"FALLING SHADOW" REPORTS

Dr. John Q. Stewart, of Princeton University Observatory, whose article in the May issue of this magazine pointed out the unusual opportunity to study the moon's "falling shadow" at the recent eclipse, reports that good response has resulted from his request for observations of this effect. Several hundred reprints of the article and mimeographed questionnaires were distributed in advance of the eclipse. Through the efforts of the United States Forest Service, this advance material reached fire lookout stations in the eclipse region via infrequently traveled mountain trails.

At the end of August, reports and returned questionnaires had come in from 145 observers in 45 parties, from stations in California, Oregon, Idaho, Montana, and Saskatchewan. Five separate groups observed at nearly exact sunrise in the vicinity of Cascade, where the sky was almost completely clear. Plenty of light was scattered into the narrow shadow from the northwest and southeast; ordinary newspaper print could be read during totality at many stations, and the only planets and stars seen were Venus, Saturn, and Capella.

Dr. Stewart plans to publish a complete account of the results of these observations, including those of his own party at Malta, in *Popular Astronomy*. He writes: "The reports speak well for the alertness and proficiency of the laymen and the scientists from fields other than astronomy who devoted a great deal of effort to making the observations, in many cases at spots difficult of access."

ECLIP

Secretary

Totality over the continental divide. The first two images, of the partial phase, were considerably overexposed. Photo by Leavens and Plachy.

THE FIRST REACTION of the writer on returning from the July 9th eclipse expedition was that it was certainly "all a dream." This is not to say that the majestic spectacle of a total eclipse was not impressive, but rather that there was so much planning and activity crowded into so very few days that, even as this is written, there has been hardly enough time to absorb the deep satisfaction from all that happened between July 5th and July 10th.

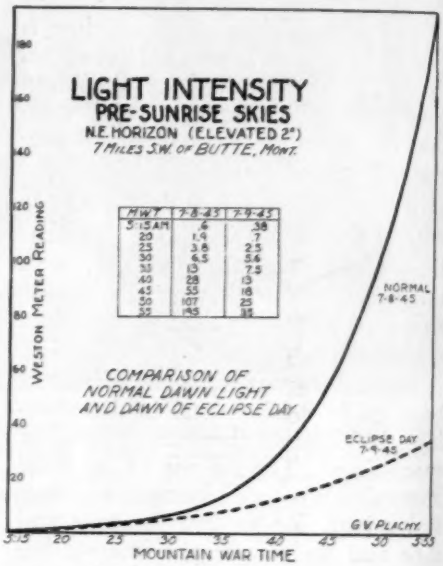
An A.A.A. eclipse expedition was in the discussion stage many months ago. The first concrete plan was to charter a commercial airlines plane to carry 15 members, but at the last minute no plane was available and not enough people were willing to share the cost, of which transportation alone was several hundred dollars per person.

With the eclipse just a few days off, we met with extreme good fortune in the matter of airplane transportation. The Sperry Gyroscope Company, of Great Neck, N. Y., agreed to integrate one of its aircraft-instrument research flights with our plans. The Sperry Company made available a Lockheed Hudson experimental plane, which could seat three or four persons besides the crew of pilot, flight engineer, and project engineer. An accompanying Douglas Dauntless also made the trip, carrying a flight engineer to assist in servicing either plane if the need should arise. Our personnel consisted of Dr. C. S. Brainin, president of the A.A.A., Peter Leavens, chief photographer, and the writer. By arrangement with *Life* magazine, one of their photographers accompanied us.

In line with the purposes and policy of the association concerning public education in astronomy, we proposed to devote a good part of our program to "spectacle" photography, that is, to the type of eclipse photograph which would be of striking interest to the layman and might be expected to arouse his interest in astronomy in general. It seemed best, therefore, to choose a location near Butte, Mont., where totality would occur near sunrise and photographs would include some horizon and landscape. The chart on the opposite page gives a summary of our operations schedule, whereby we were to photograph all phases of the eclipse in still and motion pictures, both in color and black and white. A pair of 10x50 binoculars was taken for visual observations.

Departure was from the Sperry-MacArthur airport near Sayville, Long Island, on Thursday afternoon, July 5th, our first stop to be Minneapolis, Minn. At last we were under way on a journey of almost 5,000 miles round trip, across 10 states and three of the Great Lakes, over three Canadian provinces, and to within 400 miles of the west coast. We stayed overnight in Minneapolis, and by Friday evening had crossed the continental divide four miles east of Butte; in landing there we had to lose 4,000 feet of altitude without too much area for approach circling. We made our headquarters at the Hotel Finlen.

There we were promptly met by Dr. S. R. B. Cooke, of the Montana School of Mines, who suggested a possible observing site. It was on the famous old Beef Trail, about seven miles southwest of Butte, and reasonably accessible. The location was ideal, a 6,600-foot ridge in the Deer Lodge National Forest, well open to the entire horizon, and overlooking Little Basin Creek valley. Rehearsal Sunday morning found the sun rising eight minutes later than provided for in our schedule, but the program was easily adjusted.



That rehearsal began when we left the hotel at four o'clock in the morning, for it was not a simple matter to get our equipment, transported by taxi and truck, up the steep and winding mountain trail. Time for setting up our apparatus was carefully noted, and exposure meter readings of the light intensity of Sunday's normal dawn were taken, to compare with the next day's eclipse dawn.

Saturday evening at the hotel we

General view of the site and equipment. M. B. Frantz is at the binoculars at extreme left; Peter Leavens is at the cinemachinery; James Allopenna operates the 10-foot camera shutter; Robert Roe is using field glasses; W. Wilgus holds the camera alongside Dr. C. S. Brainin (arms folded); Eric Schall ("Life" photographer) is at the extreme right. Photo by the author.

* ECLIPSE SAGA—I—was the author's report of the expedition to Florida by the New York City Amateur Astronomers Association to observe the annular eclipse of April 7, 1940. See The SKY, May, 1940.

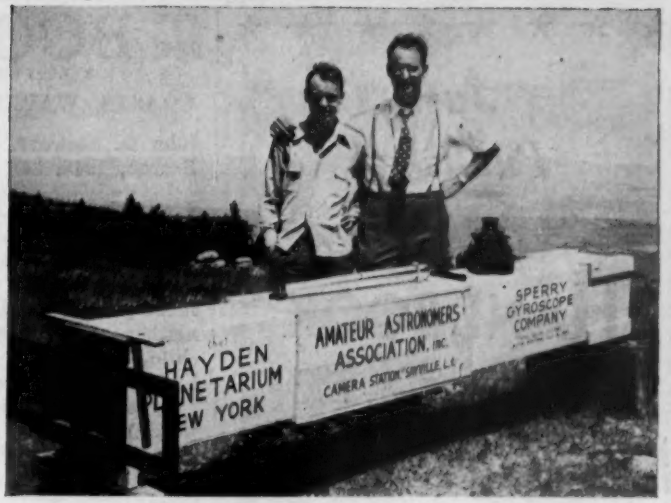
SAGA---II*

GEORGE V. PLACHY
Astronomers Association

met one of our members, M. B. Frantz, who had come all the way from New York by bus, and who offered to join in our program. On Sunday another A.A.A. member, Peter Edel, arrived via plane and train, with several pieces of photographic apparatus and telescopes to execute an ambitious program of his own.

Sunday evening was well occupied with loading plateholders, minutely checking all cameras, and ironing out details of the operating schedule.

Eclipse morning arrived with clear skies. Our party left the hotel at three o'clock, with Dr. Cooke's group, and a police escort to establish control of sightseeing cars which might try to ascend the ridge. Our equipment was set up without a hitch and the second set of light-intensity readings was taken to compare with those of Sunday.



Peter Leavens (left) and the author, with the collapsible 10-foot camera, at the eclipse site. In the distance is the continental divide just east of Butte. Photo by Dr. Brainin.

At 5:29 came Dr. Brainin's warning of operation No. 1, and we began faithfully to follow our schedule. Dr. Brainin co-ordinated the entire program by reading aloud each operation as it was to be performed, preceded by a one-minute warning. The only real difficulty came at the 6:13 motion-picture operation which was timed to start a very few seconds before totality. Since the phenomena of Baily's beads and the diamond ring came within three or four seconds of each other, we were caught somewhat off guard. However, the purely mechanical operation of taking the motion pictures was done smoothly and ran well into the total phase. We now know that the film magazine was defective and the few seconds lost would not have given the desired results anyway.

At second contact, Baily's beads were clearly seen, with a closely following diamond ring effect. Almost immediately, totality was upon us. Between photographic duties, the writer had just a five-second look. The corona color was purest pearly white, and there was no mistaking the red filaments of the prominences. The shadow of the moon, extending up from the horizon on both sides of the eclipsed sun, provided a totally unexpected aspect to the general view of totality over the mountains. The sun seemed to be in the spout of a gigantic shadow-funnel.

Third contact quickly merged totality with the final crescent phases, and the normal sky lighting began to return. The hushed spectators broke into gleeful chatter, and in a few minutes most of the sight-seers had started back to town. At 6:40, we participated in an NBC broadcast arranged at the eclipse site. Later, we telegraphed reports to New York and London newspapers.

During our work on the ridge top, the Douglas Dauntless escort plane flew overhead and the fliers made visual observations of the progress of the moon's shadow across the landscape. They clearly saw the earth

(*Continued on page* 15)

AMATEUR ASTRONOMERS ASSOCIATION, NYC. SOLAR ECLIPSE EXPEDITION.JULY 9,1945
SOUTHWEST OF BUTTE, MONTANA: LAT.45°55'33"N. LONG.112°36'4"W.±

OPERATIONS SCHEDULE: PHOTOGRAPHIC PROGRAM & SUMMARY OF EVENTS

M.W.T.	Equipt.	Film	Aperture	Shutter	Notes	Object
5:30	(a)	K	Meter	1 s.		N.E. pre-eclipse dawn color.
5:30	(b) 1"Lens	K	"	16 fps.	40 sec. run	"
5:35	(c)	B&W	<Meter	1 s.	#1 of "series"	Dawn landscape silhouette.
5:40	(d)	B&W & K	f 32.	<Meter, at front lens	2 plates	"Skyglo" negs. for later shots.
5:45	(b) 1"Lens	K	Meter	16 fps.	40 sec. run	Dawn color mod. by pre-eclipse.
5:45	(a)	K	Meter	1 s.		"
5:58 Sunrise	(b) 4"Tele.	K	VAR.	Manual	Stop-motion take at 3 fps.	Partly-eclipsed sun rising.
6:02 SunUp	(d)	B&W & K	f 32.	Med.speed manual	2 shots on skyglo negs.from above.	Partly-eclipsed sun over mts.
6:04	(c)	B&W	f 45.	1/100 sec.	#2 of "series"	95% eclipsed.
6:06	(b) 8"Tele.	K	f 36.	48 fps.	Full windup run	Flaming crescent sequence.
6:09	(c)	B&W	f 45.	1/100 sec.	#3 of "series"	Last crescent.
6:11	(a)	K	Meter	1 s.	S.W. DIRECTION	Moon's shadow, counter-color.
6:13	(b) 4"Tele.	K	VAR.	24 fps. & 12 fps.	1½ minute run	Diamond ring & into totality.
TOTAL.	(b) 2"Tele.	K	f 1.6	12 fps.	1 minute run thru 2nd contact	Totality over mountains.
TOTAL.	(a)	K	f 2.	1 & 2 secs.	2 bulb exposures	"
TOTAL.	(c)	B&W	f 6.3	1 s.	#4 of "series"	"
3rd cont.	(d)	B&W & K	f 32.	Slow manual	2 exposures	Diamond ring.
6:16	(b) 8"Tele.	K	f 36.	48 fps.	Full windup run	Incr. crescent.
6:19	(c)	B&W	f 45.	1/100 sec.	#5 of "series", Final.	"
6:22 -) 6:40)	(d)	B&W	f 32.	Ultra Hi-speed	Experimental	"

(a)= Kodak Bantam Special camera f2.
(b)= B&H special cinemachinery.
(c)= Kodak regular 3A camera f 6.3
(d)= Photolunascopic camera 4"lens, 10'F.L.

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BOOKS AND THE SKY

COASTS, WAVES, AND WEATHER

John Q. Stewart. Ginn and Company, Boston, 1945. 348 pages. $3.75.

FOR MANY YEARS no book on seamanship or navigation was thought quite complete unless it had a chapter on "Weather and the Laws of Storms." A stepchild of both, it belonged to neither, and it grew like an ill-nourished child, stunted by brief treatment and limited environment. It has been the very worthwhile task of Dr. Stewart, in writing **Coasts, Waves, and Weather**, to separate the child from its pseudo-parents and to give it co-equality with them.

The title beggars the book, for between the covers is to be found much more than it suggests. The oceanographer, meteorologist, geologist, seaman, navigator, photographer, and others have contributed to every ramification of the subject, to the end that the physical phenomena of earth, sea, and air may be better understood by those whose business is upon the sea or in the air. And the whole is so attractively illustrated and engagingly presented that one loses a sense of study in the absorbing interest of its chapters.

The text of 348 pages is illuminated by more than 200 excellent photographs, most of which, it is understood, have not been published before. Where they serve to clarify or amplify, selections from sailing directions of pilot books have been included. These excerpts are happily chosen, for they come from sources containing some of the most vivid and colorful experiences to be found in the literature of the sea. This reviewer was delighted to see one on ice in the Arctic, by Capt. Healy of his own Service, written more than half a century ago. Capt. Healy was a keen, observant and intelligent officer, gifted with a facility for salty expression, oral or written, unequaled to this day. To read him is to taste the tang of salt spray.

As the title suggests, the general subject is divided into three parts. Of these Part One, which treats of land forms and sea bottoms, is of first importance, not only in the space accorded, for it covers nearly half the book, but in the nature of the text, much of which is entirely new to sea and air navigators. Here the author has enlisted the aid of the geologist in explaining the significance of different types of coast lines and how they concern the mariner in the probability of finding deep or shoal water inshore, and fair or foul ground offshore. In addition there are profusely illustrated descriptions and examples, taken from all over the world, of coral reef formations, volcanic islands, bays and sounds, capes and inlets, bars and deltas, seaports and airports, and their navigational hazards. The part closes with a discussion on the distribution of populations as affected by transportation. Part Two deals with oceanography, including tides and tidal forces, descriptions of ocean currents, waves, and ice in the sea. Part Three is a comprehensive treatise of meteorology in sea and air navigation.

In producing this work, Dr. Stewart has created a new and essential branch of the study of the sea which, while closely allied to seamanship and navigation, is subsidiary to neither. In the opinion of the reviewer, who has spent the larger part of his adult life at sea, there is so much of value to be found in this one volume that the seaman-navigator who reads it will be a better seaman and a more skillful navigator for having done so.

L. V. KIELHORN
Captain, USCG (Ret.)

ASTRONOMIE ELEMENTAIRE

Frere Robert, F.E.C. De La Salle, 949 Rue Cote, Montreal, 1945. 2nd edition.

THIS is the second edition of a good French textbook in astronomy. The first part presents the study of the earth and the planetary system in a clear and interesting manner. The author begins with a description of the sky, ways for identifying the stars, and a study of the diurnal motion of the heavens. It might have been well to emphasize further the use and significance of angular measurements, and it is surprising to find no mention of galactic co-ordinates. Also,

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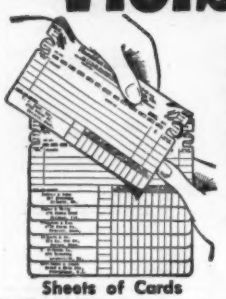
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in the chapter on instruments, the Schmidt camera is omitted.

The second part of the book is devoted to astrophysics, but the treatment of such subjects as the relation between mass and absolute magnitude, giants and dwarfs, variable stars (except for the Cepheids), is quite limited. The author also fails to mention the important topic of interstellar absorption.

Except for these defects, this is, generally speaking, a good textbook; however, it must be supplemented by the teacher, especially in the field of astrophysics.

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ECLIPSE SAGA—II

(*Continued from page* 13)

below split by a shadow line sharply etched on the rough terrain.

Our position was later determined as about two miles north of the central line, at 45° 55′.5 north, 112° 36′ west.

Taking off from Butte just before noon, we flew some 200 miles northwest for a brief aerial view of Glacier National Park, where we took many pictures in black and white and color. On the way there, we looked down the world's biggest smokestack, 586½ feet high and 86 feet in diameter, at the huge smelter of the Anaconda Copper Mining Company.

Again stopping overnight in Minneapolis, and flying high with oxygen masks, we reached Sayville in a thunderstorm on the afternoon of the 10th. But no amount of bad weather could have dampened our spirits—we were confident that most of our eclipse pictures were good.

Both of the planes had performed admirably, and the Sperry pilots and engineers had collected a large amount of data on the operation of their experimental equipment during all stages of the flight. Sperry personnel on the expedition consisted of pilots Robert Roe and B. A. Bunch, flight engineers James Allopenna and H. Willeman, and project engineer William Wilgus.

We wish to make public our thanks to the Sperry Gyroscope Company for its generous sponsorship of this expedition, especially to its president, R. E. Gillmor, director of research, Dr. Karl Frische, and general operations superintendent, Fred Smith.

Results of our photographic program have not yet been fully evaluated, but *Life* magazine has already published a full-page reproduction of the rising crescent over the continental divide, taken with the 10-foot camera and giving an image of the sun about one inch in diameter. A dozen Kodachrome transparencies, including dawn color and two good shots of totality, were taken with the Bantam Special f/2. Besides numerous other shots, we obtained in color a short section of motion picture of the rising crescent.

And now to prepare for the eclipse of 1954!

The INDEX for Volume IV

is in preparation. It will be similar to previous indexes, including title page, author, title, subject, and topic references. Send 25 cents, and your copy will be mailed as soon as printing is completed.

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OBSERVER'S PAGE

All times mentioned on the Observer's Page are Eastern standard time.

A Path-Limit Observations Program

FREQUENTLY, eclipses of the sun cross sparsely populated regions of the earth, and any program requiring a large number of observers is difficult to organize. There may be the additional problem of communication in a foreign tongue.

In 1925 and 1932, however, when the moon's shadow fell across the well-populated eastern states, it was possible to organize large numbers of observers to determine the duration of totality at various points and the position of the shadow's edge. The recent eclipse appeared to offer, in Saskatchewan at least, a similarly good opportunity for such a program, and the editors chose the edge-of-the-path problem for some attempted long-distance organizing of observers. This had been suggested by Mrs. Isabel M. Lewis, of the United States Naval Observatory, in her article in the April issue of **Sky and Telescope**, and it was with her co-operation and advice that the program went forward.

Original plans called for a personal visit to communities along the path of totality, but wartime transportation limitations precluded this. Our final expedition arrangements made it possible for us to visit two towns, Melville and Yorkton, at the edge of the path. Mrs. Margaret Back, of the Detroit Astronomical Society, volunteered to make a special trip from Wolseley to Indian Head, thereby helping to procure observations from that town.

Nearly two months in advance, a letter was sent to the editors of a selected list of 31 newspapers in Saskatchewan and four in Manitoba. Material sent out included: (1) A full-length feature story on eclipses and describing the eclipse as it would be seen from both inside and outside the path. (2) A mat for newspaper reproduction showing the crescent, Baily's beads, and the corona. (3) A set of questionnaires for observers. (4) A set of instructions to supervisors. (5) A letter to the editor requesting his co-operation in soliciting the aid of a local teacher, minister, lawyer, or other person as supervisor of the observations. (6) A photostat of a map of the eclipse region in Saskatchewan and western Manitoba, with the predicted path plotted.

The response to this letter failed to come up to expectations. Although we later learned that a number of the newspapers had used the article and pictures, only a few apparently were able to carry out the rest of our proposals, and it is evident that the approach might better have been made to a high school science teacher or the like. Many of these towns, however, have very small populations and only limited school facilities, which was one reason we chose the papers. We also hoped in this way to reach out-of-town subscribers who might be strategically located along the edge of the path.

Mrs. Lewis had suggested that observers be at intervals of ¼ or ½ a mile across these limits, but that it was better if the observers did not know in advance the exact predicted limits. In the **Ephemeris Supplement**, the limits are computed to the nearest minute of arc (nautical mile) on page 18, and to the nearest 1/10 mile on page 14. Mrs. Lewis stated that later, accurate predictions could be computed for specific points from which observations were received, to compare with observed data.

Astronomers generally consider the appearance of the flash spectrum as marking the instant of second contact, but visual observation of this is possible only with a prism or grating. Our questionnaire was based on the breaking up of the last remaining crescent into Baily's beads, and the possible disappearance of these beads for from a brief instant (for an observer just inside the path) to a few seconds. The questionnaires, to be filled out on the spot by persons without scientific training, were designed to be as brief as possible, without ambiguity. Inconsistencies in the responses indicate desirable changes which might be made for a future program of this type.

Supervisors were asked to provide the exact location of each observer. This task was made admirably easy because of the system of dividing the region into townships containing 36 mile-square sections, which in turn are in quarter sections. The quarter-section-range-township position locates an observer on the corner of or inside a square a quarter of a mile on a side, and detailed section maps are easily available from the Department of Mines and Resources, at Ottawa.

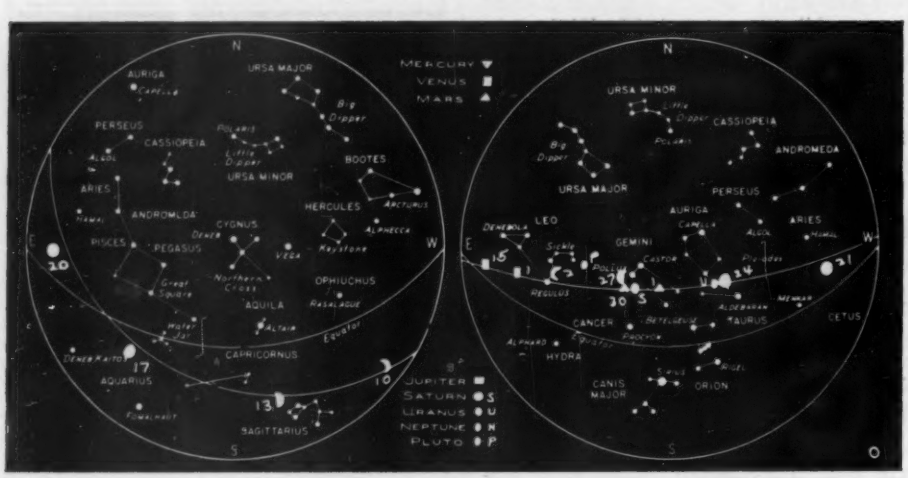
At this writing, we have not had time to make a complete study of those few groups of observations which hold promise of giving a definite line for the limits, but the following represents the total of reports on hand.

At Indian Head, Editor T. S. Newman, of the Indian Head **News**, did the organizing himself, finding several college students and others to act as observers. Unfortunately, he sorted his returns and sent in only five reports, but we have requested that the remainder be sent. He and others three miles east of town reported about five seconds of totality.

At Milestone, Publisher J. E. Willoughby, of the Milestone **Mail**, apparently had difficulty finding a supervisor, but he showed considerable interest in the project, and volunteered to supervise observing himself, if necessary. No edge-of-the-path reports came from this vicinity, but Milestone saw about 23 seconds of totality.

At Yorkton, Editor S. N. Wynn, of

THE MOON AND PLANETS IN THE EVENING AND MORNING SKIES



In mid-northern latitudes, the sky appears as at the right at 5:30 a.m. on the 7th of the month, and at 4:30 a.m. on the 23rd. At the left is the sky for 7:30 p.m. on the 7th and for 6:30 p.m. on the 23rd. The moon's position is given for certain dates by symbols which show roughly its phase. Each planet has a special symbol, and is located for the middle of the month, unless otherwise marked. The sun is not shown, although at times it may be above the indicated horizon. Only the brightest stars are included, and the more conspicuous constellations.

Mercury passes into the evening sky, but sets only about 40 minutes after the sun by the end of the month.

Venus is in the morning sky, in Leo. It passes close to Jupiter on the morning of the 30th.

Mars is in Gemini, and rises before midnight. It is in close conjunction with the moon the night of the 26-27, and will be occulted for some stations. (See occultations data.)

Jupiter crosses into the morning sky on the 1st of the month, and is in conjunction with Venus on the 30th.

Saturn rises by about 11 p.m. the middle of the month, in Gemini. It is in conjunction with Mars the morning of the 26th.

Uranus is in Taurus.

Neptune is too near the sun for favorable observation.

Pluto is in Cancer.

the Yorkton **Enterprise**, had an obvious choice for supervisor in Mrs. Robert Priestly, president of the Yorkton Natural History Society. She put a great deal of effort into distributing questionnaires among her scientifically minded associates. Unfortunately, the Bredenbury clouds during the eclipse had their source northwest of Yorkton, so Mrs. Priestly's well-organized group, which included 15 persons, was clouded out. She and her husband, manager of radio station CJGX, were twice our hospitable hosts as we passed to and from Bredenbury.

At Melville, a town practically split by the shadow's edge, better weather prevailed, and we have a dozen reports from scattered observers in that region. The supervisor here was young Bert Dukowski, whose father, a former professional hockey player, conducts what must be the best hotel anywhere northeast of Regina.

From Kipling, Mrs. Muriel Hutton, news editor of the Kipling **Citizen**, sends a report placing her definitely outside the shadow, but she did see Venus.

From Windthorst, Mrs. W. C. McArton, correspondent of the Windthorst **Independent**, sent in seven promising reports from observers in Kegworth, Peebles, and Windthorst, which represents a line right across the southern side of the path.

At Regina, as part of the series of articles written in the Regina **Leader-Post** by amateur H. S. McClung, the questionnaire was reproduced, and it brought 17 replies from persons as much as 50 miles outside the path. Unfortunately, few of these observers were near the path edges, but the value of such widespread publicity was demonstrated for future use.

The overall picture of these reports indicates the need for personal contact with both the supervisors and as many individual observers as possible; undoubtedly, this is a decision many other organizers of observations by the public have had to come to in the past. With wartime restrictions out of the way, future eclipses such as that of 1954 offer promise for useful projects of this kind.

C. A. F.

PHASES OF THE MOON

New moon .....October 6, 0:22 a.m.
First quarter ....October 14, 4:38 a.m.
Full moon .....October 21, 0:32 a.m.
Last quarter ....October 27, 5:30 p.m.

MINIMA OF ALGOL

October 9, 3:55 a.m.; 12, 0:43 a.m.; 14, 9:32 p.m.; 17, 6:21 p.m.; 29, 5:36 a.m.

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ECLIPSE NEWS FROM EUROPE

IN A LETTER to Dr. Harlow Shapley, director of Harvard College Observatory, news is received of the success of a French eclipse expedition. The letter was sent V-mail from Paris, July 25th, by Dr. G. P. Kuiper, of Yerkes Observatory, and reads in part:

"The expedition was on the Swedish Baltic coast, latitude, I believe, 64° 50'. The weather was good, a sea breeze blowing the clouds off into the mountain area. The French party consisted of Lyot, Chalonge, Barbier, Miss Cannavaggia, LeClerc, and Dauvillier.

"Lyot took polarization photographs of the corona with a yellow filter, in orientation NS and EW (heliographic). The photographs came out well, though a little lighter exposure might have been better. The plates will give the polarization of the corona far out.

"Chalonge, Barbier, and Miss Cannavaggia took slit spectra of the solar limb, with similar spectra of the center of the disk for comparison. The spectra range from 3200-6600A and are about 16 centimeters long. They are of good quality. The exposure times were measured with an oscillograph. LeClerc took moving pictures, black and white, of the corona, plus colored stills.

"The Swedish expedition was in the same locality near the coast. Lindblad made a determination of the precise times of contact by means of movie records of the limb spectrum; Ohman studied the polarization of the corona and obtained flash spectra. Their program was outlined in the **Observatory** of June; it appears to have been carried out satisfactorily."

A copy of the London **Times** dated June 24th, and received by Fred Garland, Pittsburgh, from H. E. Kersey, Ipswich, states that wartime difficulties made it impossible for England to send out any eclipse expeditions.

A letter dated August 6th from Dr. Carl Schalén, of Upsala Observatory, Sweden, has been forwarded to us for publication through the kindness of Dr. A. N. Vyssotsky, of Leander McCormick Observatory. Dr. Schalén writes in part:

"During the summer I was in the northern part of Sweden to observe the eclipse. Unfortunately, the weather was bad during the eclipse, so that we did not see the corona; occasionally we could see the partial phases through the clouds. From the 18th of June it had been clear practically every day, and 20 minutes after totality it was again clear!

"We had on our program the photometry of the corona in three colors, and photography of the flash spectrum to get the times of second and third contacts as accurately as possible.

"Our expedition was located 100 kilometers from the coast, at Norsjo, but expeditions near the coast had excellent weather conditions."

Newspapers have reported that 12 expeditions were located at Skelleftea, Sweden, to observe the eclipse, and that more than 20 Soviet groups were assembled along the path of totality.

OCCULTATION PREDICTIONS FOR OCTOBER

13-14 **208 B Sagittarii** 6.2, 19:12.2 —24-16.5, 7, +64° +1° Im: E 1:59.6 —1.3 —0.2 61°; F 1:48.8 —2.1 —0.1 75°; G 1:35.7 .... 18°; H 1:01.4 —2.5 +1.4 52°.

15-16 **27 Capricorni** 6.2, 21:06.4 —20-46.7, 9, +70° +5° Im: A 3:35.0 —1.4 —1.6 101°; C 3:33.9 —1.7 —1.7 105°; D 3:24.2 —1.4 —1.0 22°; E 3:08.8 —1.7 —0.4 80°; F 2:58.2 —2.6 —0.5 93°; G 2:38.4 —1.2 +0.9 39°; H 2:11.2 —2.0 +1.3 58°; I 2:24.9 —1.3 +1.4 35°.

16-17 **29 Aquarii** 6.5, 21:59.4 —17-13.8, 10, +70° —5° Im: A 2:01.6 —1.1 +0.9 36°; B 2:03.7 —0.8 +1.1 27°; C 1:52.4 —1.3 +1.2 36°; D 1:56.4 —0.9 +1.5 22°; E 1:38.7 —0.9 +2.4 11°; F 1:05.0 —1.7 +2.4 30°; H 0:53.8 .... 357°.

18-19 **30 Piscium** 4.7, 23:59.1 —6-19.2, 12, +84° —1° Im: B 6:55.2 —1.4 —3.4 122°; D 6:51.8 —1.8 —3.5 122°; E 6:38.8 —2.4 —2.8 117°; G 5:57.8 —1.1 +0.7 50°; H 5:36.8 —1.9 +0.8 70°; I 5:46.8 —1.0 +1.2 41°.

24-25 *1* **Geminorum** 4.3, 6:00.8 +23-16.1, 18, +42° —18° Im: C 11:00.0 —2.4 +4.4 22°; E 10:34.3 .... 22°; F 9:56.2 —2.2 +1.3 66°; H 9:43.8 .... 9°. Em: C 11:30.3 .... 336°; E 11:10.0 .... 330°; F 11:19.9 —2.3 —0.9 281°; H 10:12.6 ...., 326°.

26-27 **MARS** 0.3, ..., 20, +90° +25° Im: A 4:03.3 .... 174°. Em: A 4:07.8 .... 183°; E 4:24.1 +0.9 +2.3 218°.

For selected occultations (visible at three or more stations in the U. S. and Canada under fairly favorable conditions), these predictions give: evening-morning date, star name, magnitude, right ascension in hours and minutes and declination in degrees and minutes, moon's age in days, limiting parallels of latitude, immersion or emersion; standard station designation, G.C.T., **a** and **b** quantities in minutes, position angle; the same data for each standard station westward.

Longitudes and latitudes of standard stations are:

A +72°.5, +42°.5 **B** +73°.6, +45°.6
C +77°.1, +38°.9 **D** +79°.4, +43°.7
E +91°.0, +40°.0 **F** +98°.0, +30°.0
G +114°.0, +50°.9 **H** +120°.0, +36°.0
I +123°.1 +49°.5

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude respectively, enabling computation of fairly accurate times for one's local station (long. **Lo**, lat. **L**) within 200 or 300 miles of a standard station (long. **LoS**, lat. **LS**). Multiply **a** by the difference in longitude (**Lo — LoS**), and multiply **b** by the difference in latitude (**L — LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Greenwich civil time to your own standard time.

For additional occultations consult the **American Ephemeris and Nautical Almanac** and the British **Nautical Almanac**, from which these predictions are taken. Texas predictions were computed by E. W. Woolard and Paul Herget.

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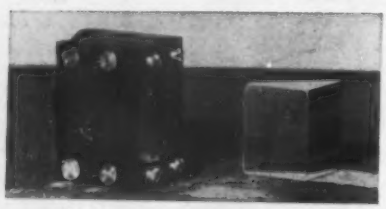

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From Start to Finish—12

By ALLYN J. THOMPSON

XIII—IN DEFENSE OF THE REFLECTOR

Recently, there has been made a powerful plea for the application of more common sense in the construction of the reflector, and an appeal to all telescope makers to give due weight to the specific problems of its design, "thus hastening the day when the reflector will attain its rightful position alongside the refractor in work of delicate visual resolution."

Frank Vaughn, author of this plea,[1] says, "There has been a considerable flow of ink in the past several years concerning the relative merits of refractor and reflector so that discussion along lines already much written about would be largely superfluous." He then cites at some length the important features and failures of telescope design, with the observation that "the reflector seems to have degenerated into a nondescript handyman's plaything of an idle hour."

Six salient features are emphasized by Mr. Vaughn: quality of figure on the primary mirror; ditto on the diagonal; definition vs. focal ratio; diffraction effects from the spider arms; geometric support for the mirror; tube diameter and insulation. The writer is pleased to note that in the currently concluding series of articles, all of these features have been accorded due emphasis.

Many amateurs feel that their mirrors are inferior to the professionals', but this is not necessarily true. As Mr. Vaughn points out, mirrors of professional make will seldom stand up to a test because "it is impossible for the professional maker to spend a sufficient amount of time on a mirror without losing money," whereas the amateur can, if he will, indulge all the time necessary to produce a mirror of admirable figure. Yet, having figured his mirror to within perhaps one eighth of a wave length of the paraboloid, he frequently uses for a diagonal a piece of plate glass that may be half a dozen wave lengths off from flatness, and cylindrical to boot.

Mr. Vaughn criticizes efforts to stiffen the diagonal support by increasing the thickness of the spider arms, and so also increasing the amount of resulting injurious diffraction effects. Perhaps a minimum thickness of metal that will safely resist stretching or shearing is about .012". Such material is used in the author's 8-inch reflector (10" tube), and the diagonal is as steady as a rock, and diffraction is kept at a minimum.

1 "Important Considerations in Making Reflecting Telescopes," Frank Vaughn, Journal of the Royal Astronomical Society of Canada, February, 1945.

Reward

If you can grind two discs of glass together
With steady, even, measured stroke and slow;
If you can carry on in spite of weather,
Through summer heat or winter cold and snow;
If you can persevere when all pals flout you
But make allowance for their flouting too;
Nor yet get mad while people round about you
Are laughing at the funny things you do;

If you can read each evanescent shading
The moving knife-edge throws before your eyes
And learn from them your mirror's perfect grading
Will ease your work when you parabolize;
Yet not give up nor yet become desponding
Nor chuck the mirror far across the hedge
When tests give you the shadows corresponding
To deep hyperbola or turned down edge;

If during all the hours it takes to figure
You do not lose the mirror-maker's touch,
Nor when it passes all its tests with rigour
You do not get elated over-much;
Why then, when set within its goodly mounting
And you look back upon a job well done,
Yours are the skies, their glories past all counting,
For you'll have made a telescope, my son.

From the R.A.S.C. *Journal*, April, 1942 H. BOYD BRYDON

In passing, it might be mentioned that by properly shaping and locating the spider arms, the objectionable diffraction effects can be eliminated,[2] but this improvement is best not attempted by the beginner.

Focal ratio was briefly discussed in our opening chapter, but another phase of it is mentioned by Mr. Vaughn. Thanks to its perfect achromatism, the reflector can be designed in very low focal ratios, commonly f/4 to f/8. On the other hand, the refractor must be designed at about f/15 in order to keep chromatic aberration at a minimum, and at that focal ratio it does give superior definition. But except for the diffraction from the obstructing spider arms, and thermal disturbances inside its open tube, the reflector is, size for size (aperture and focal length), the equal of the refractor.

Nevertheless, there does seem to be a spreading trend, much of which is purely conversational, toward the refractor. Now, it is just as commendable to build that kind of a telescope as it is to build a reflector, so long as there is a good reason for doing so. But when the reason stems from dissatisfaction with a reflector, it is time to examine the source of the trouble. The author has had opportunity to observe through a number of such unsatisfactory, amateur-made telescopes, and to test numerous mirrors that have been in use. Almost invariably, the owner's plaint has been that "there is something wrong." And, indeed, there was.

In most cases, the mirrors, several of them of professional make, were at fault. Hyperboloidal mirrors, many with nondescript curves, grossly overcorrected, turned-down edge zones, and astigmatism, the latter sometimes resulting from flexure from poorly designed cells, represented the predominating mirror faults. Frequently were found cheap plate-glass diagonals, far too small, or cheap prisms, equally bad; thick spider arms; misalignment of the optical parts; insufficient or inefficient adjustments on the several parts, so that alignment was either impossible to be had, or impossible to maintain. Focusing was often difficult, and the eyepieces were of inferior quality. Many of the telescopes were crudely or frailly mounted. One or more of these defects was present in all of the instruments examined.

The disillusioned amateur then compares what he sees in his telescope with views through a refractor at some observatory, or through one owned by a wealthy friend, on which has been lavished all of the skill of the professional optician and instrument maker. In desperation, therefore, he clamors for a refractor, heedless of the precision of radius that must be given to each of the four surfaces, and in complete disregard of his failure to make a worthy reflector. It is safe to assume that his refractor would be equally poor, produced at not less than five times the cost of the Newtonian. Not all of the blame should be placed on the amateur. Often in the past, he has been told how to grind and polish his mirror, and then been left to produce, willy-nilly, a paraboloid.

Conflicting reports concerning such problems as temperature changes have increased his worries. The writer has recently made an effort to determine the actual effect of changing temperature within the substance of the mirror, long known to be a factor in definition.

Five pyrex mirrors, four with excellent paraboloidal figures, and one spherical, were immersed on different occasions in warm water (96° F.), and cold water (46° F.), for half-hour periods, and tested after each immersion on the Foucault stand in a room having a temperature of 68° F. These temperature differences, 28° and 22° respectively, are believed to be no greater than may be frequently encountered by the amateur and his telescope. The results of the tests are given in the accompanying table. In the third column is the amount of measured correction on the mirrors after removal from the

Size of mirror	*Normal corr. (r^2/R)*	*Cooling*	*Return to normal*	*Warming*	*Return to normal*
6" f/4	.18"	.18"	.....	.18"	.....
6" f/8	.09"	.14"	25 min.	Spherical	30 min.
8" f/5	.20"	.21"	.....	.20"	.....
8" f/8	.13"	.19"	35 min.	.05"	30 min.
6" f/9	Spherical	Ellipsoid (.07")	30 min.	Oblate (—.07")	30 min.

2 "Scientific American," June, 1945.

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12-inch	96 "	200.00

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20 mm.	95 "	2.00
18 mm.	95 "	2.00

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warm water, and in the fifth column the correction after removal from the cold water. In the fourth and sixth columns are given the times elapsed before the figures returned to their normal values.

Apparently the figures of mirrors of small focal ratio are little affected by changing temperature, whereas the change in figure of mirrors of high ratios may be very pronounced. In the testing of the f/8s and the f/9, the knife edge had to be constantly shifted in order to keep pace with the constantly changing figures. And at intervals, far beyond the time required for the figures to return to normalcy, the air in front of each mirror would boil and seethe with convection currents, indicating that for a considerable period satisfactory observing might be difficult.

The findings in the third column, where increased correction is evident, represent the conditions that are prevalent to a more or less degree in the lowering temperatures of nightfall, when an amateur most frequently undertakes observations. It has in the past been advocated that a mirror be left undercorrected, on the premise that where there is a gradual fall in temperature over a period of hours, during which the temperature of the mirror is lagging behind that of the atmosphere, the consequent increase in correction would bring the figure up to a paraboloid.

It seems to have been overlooked that this predication was made for plate-glass mirrors, in the days when pyrex was unknown, and may have worked very well, assuming that the amount of undercorrection to be given to the mirror could be calculated to a nicety. Pyrex is insensible to small temperature differences, and for extreme conditions like those in the test it was found that a fixed focus could not be maintained during the period of adjustment. Thus, useful observation during that interval would be out of the question. When the mirror does catch up, which it shortly does, it resumes its normal figure anyway, so if one has the skill, there is no reason why a mirror should not be given the full measure of correction as prescribed by the r^2/R formula.

For the beginner, too, making a suitable diagonal has seemed to be a laborious amount of work. He is not necessarily an inventor, and the making of mechanical parts, and what they are supposed to do, has probably never been satisfactorily explained to him. Description of a simple, yet practical mounting has scarcely been attempted. For ready-made parts, accessories, and the like, he has been at the mercy of dealers whose business it is, first, to make money. Too often, a dealer will select a couple of lenses that will yield an image, mount them in a cell, assign a focal length (and a price) to them, and offer them for sale as eyepieces. This practice was particularly frequent during the war years, so we are pleased to note the return to eyepiece production of several firms whose products, if of pre-war quality, are dependable.

Care, good judgment, and a thorough understanding of what is being attempted should enable the amateur to produce a reflecting telescope that will not leave him yearning for a "cure-all" refractor, but will prove to be an instrument he can thoroughly enjoy using, and one that will enhance his knowledge of the universe around us.

THE END

ACKNOWLEDGMENT

The writer wishes to mention that A. W. Everest, of Pittsfield, Mass., is the originator of the shadow method of testing the paraboloidal mirror, described in Part 5, March, 1945. A discussion of this method, by Mr. Everest, first appeared in the book *Amateur Telescope Making*, and again, more completely, in *Amateur Telescope Making Advanced*.

SKY-GAZERS EXCHANGE

Classified advertisements are accepted for this column at 30c a line per insertion, 7 words to the line. Minimum ad 3 lines. Remittance must accompany orders. Address Ad Dept., Sky and Telescope, Harvard College Observatory, Cambridge 38, Mass.

FOR SALE: Equatorial mountings for telescopes, three sizes. Small inventions developed. C. C. Young, 25 Richard Road, East Hartford 8, Conn.

FOR SALE: 3" (75 mm.) Selsi refractor; altazimuth mount on tripod; three eyepieces, terrestrial 50x, celestial 70x and 155x. ALSO 4¼" (108 mm.) Vion refractor; altazimuth mount on sturdy tripod; four eyepieces, terrestrial 75x, celestial 110x, 150x, and 230x. Both instruments are packed in original cases, and are in absolutely perfect condition. Write or call Mrs. Jesse A. Fitzpatrick, 248 Center Ave., New Rochelle, N. Y., N.R. 2-3366.

WANTED: Fine quality telescope with 2½" to 6" objective. Give full description and price. Joe W. Grace, 309 Cliff Towers Hotel, Dallas 8, Tex.

WANTED: ¾" Ramsden or Kellner ocular, amateur or professional make. Send specifications to Kenneth Widing, 611 North Fifth St., Brainerd, Minn.

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FOR SALE: 6" pyrex objective. Rough and fine ground to f/10 curve. Price $10.00. John Riggs, 1248 8 St., Port Arthur, Tex.

FOR SALE: 8x40 (Delactis) Zeiss binoculars, excellent condition, price $165.00; ½" and ¼" Ramsden eyepieces. Eugene Zartarian, 560 Audubon Ave., New York 33, N.Y.

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PLANETARIUM NOTES

Sky and Telescope is official bulletin of the Hayden Planetarium, 81st Street and Central Park West, New York City, and of the Buhl Planetarium, Federal and West Ohio Streets, Pittsburgh, Pa.

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★ **THE HAYDEN PLANETARIUM** presents in *October*, AUTUMN SKIES. (See page 3.)

In *November*, COMETS AND METEORS. "Falling" and "shooting" stars have attracted the attention of man from earliest times. Meteors in the sky—meteorites upon the earth—what are they? Why do we at regular intervals observe showers of meteors? What happens to the earth when it passes through a comet's tail? In November in the Hayden Planetarium you will see a meteor shower—thousands of shooting stars in a single night—and one of the most beautiful of all comets with a tail millions of miles long.

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NEWS NOTES

(*Continued from page 5*)

have been found in these late spectral subdivisions. Moreover, their distribution in space is limited, leading the authors, O. J. Lee and T. J. Bartlett, to a conclusion which they admit sounds like "special pleading," namely, "that these types are very scarce and that they have special distribution relatively near us in space."

A list of 87 very red stars of another class, the carbon stars (classified as *R* and *N*), confirms a previous conclusion from the first list. These stars are found mainly in the Milky Way, being most numerous in the anticenter region.

How are these distributions to be accounted for? Are carbon compounds and titanium oxide irregularly distributed, with an unusually abundant supply present in our branch of the Milky Way, favorable to the birth of these unusual stars? Or is our branch of the galaxy in a critical, unexplained stage of evolution, "either too young or too old"?

A SOLAR FIASCO

Although B. C. Parmenter, of the Black Forest Observatory at Seattle, Wash., knew the sun would rise on July 9th after mid-eclipse time had passed, he prepared to photograph the waning partial phases in rather unique fashion. He and his wife drove their car to a hilltop 10 miles from the city, and there made a *camera obscura* of the inside of their car by covering the vehicle completely with blankets. They used a 2-inch projection lens to obtain a 12-inch image on a screen inside the car, and took four pictures of this projected image with, presumably, a hand camera.

That afternoon, in the darkroom, Mr. Parmenter discovered an extra strip of paper material on the emulsion side of the roll of film, and to his complete chagrin found every one of his pictures a blank! He wants to know if he should blame his ill fortune on the war.

HERE AND THERE WITH AMATEURS

This is not intended as a complete list of societies, but rather to serve as a guide for persons near these centers, and to provide information for transplanted amateurs who may wish to visit other groups. The asterisks denote societies whose members receive *Sky and Telescope* as a privilege of membership.

City	*Organization*	*Date*	*P.M.*	*Season*	*Meeting Place*	*Communicate with*
BOSTON	*Bond Ast. Club	1st Thu.	8:15	Oct.-June	Harvard Obs.	Miriam Bond, Harvard Observatory
"	*A.T.M.s of Boston	2nd Thu.	8:15	Sept.-June	Harvard Obs.	F. A. Pflug, 685 Centre St., Jamaica Plain
BROOKLYN, N. Y.	Astr. Dept., B'klyn Inst.	Rd. Table 3rd Thu.	8:15	Oct.-April	Brooklyn Inst.	William Henry, 154 Nassau St., N. Y. C., *BA.* 7-9473
BUFFALO	A.T.M.s & Observers	1st, 3rd Fri.	8:00	Oct.-June	Mus. of Science	J. J. Davis, Museum of Science
CHATTANOOGA	Barnard A. S.	4th Fri.	7:30	All year	Chattanooga Obs.	C. T. Jones, 326 James Bldg., *CHat.* 7-1936
CHICAGO	*Burnham A. S.	2nd Tue.	8:00	Sept.-June	Chi. Acad. of Sciences	Miss W. Sawtell, 928 N. Harvey, Oak Park
CINCINNATI	*Cin. A.A.	2nd Fri.	8:00	Sept.-June	Cincinnati Obs.	Dan McCarthy, 1622 DeSales Lane
CLEVELAND	Cleveland A. S.	Fri.	8:00	Sept.-June	Warner & Swasey Obs.	Virginia Burger, Warner & Swasey Obs.
DAYTONA BEACH	D. B. Stargazers	Alt. Mon.	8:00	Nov.-June	500 S. Ridgewood Ave.	Rolland E. Stevens, 500 S. Ridgewood
DETROIT	*Detroit A. S.	2nd Sun.	3:00	Sept.-June	Wayne U., Rm. 187	E. R. Phelps, Wayne University
"	*Northwest A. S.	3rd Tue.	8:00	Sept.-June	Redford High Sch.	E. P. Holleran, 12305 Turner Ave.
DULUTH, MINN.	Duluth Ast. Club	Meetings suspended				Ray S. Huey, 1822 E. 3rd St.
FT. WORTH	Tex. Observers	No regular meetings				Oscar E. Monnig, 1010 Morningside Dr.
GADSDEN, ALA.	Ala. A.A.	1st Thu.	7:30	All year	Ala. Power Audit.	Brent L. Harrell, 1176 *W* or 55
HOUSTON	Houston A. S.	Last Fri.	7:30	All year	Mus. Nat. Hist. Annex	Nathan Miron, 4310 Elsbury
INDIANAPOLIS	Indiana A.A.	1st Sun.	2:15	All year	Odeon Hall	E. W. Johnson, 808 Peoples Bank Bldg.
JOLIET, ILL.	Joliet A.S.	Alt. Tue.	8:00	Oct.-May	Jol. Mus. & Art Gall'y	Mrs. Robert L. Price, 403 Second Ave.
LOS ANGELES	L.A.A.S.	2nd Thu.	8:15	———	2606 W. 8th St.	A. M. Newton, 2606 W. 8th St.
LOUISVILLE, KY.	L'ville A.S.	3rd Tue.	8:00	Sept.-May†	University Center, Univ. of Louisville	Mary Eberhard, 3-102 Crescent Ct. *Taylor* 4157
MADISON, WIS.	Madison A.S.	2nd Wed.	8:00	All year	Washburn Obs.	Dr. C. M. Huffer, Washburn Obs.
MEMPHIS	A.T.M.s of Mem.	Alt. Tue.	7:30	All year	Private houses	James Woody, 1056 Linden Ave.
MIAMI, FLA.	Southern Cross A.S.	Every Fri.	7:30	All year	M. B. Lib. Grounds	A. P. Smith, Jr., 426 S.W. 26th Road
MILWAUKEE	Milw. A.S.	1st Thu.	6:15	Oct.-May††	City Club	E. A. Halbach, 2971 S. 52 St.
MOLINE, ILL.	*Pop. Ast. Club	Wed.†††	7:30	Feb.-Nov.	Sky Ridge Obs.	Carl H. Gamble, Route 1
NEW HAVEN	New Haven A.A.S.	4th Sat.	8:00	Sept.-June	Yale Obs.	J. J. Neale, 29 Fairmont Ave.
NEW ORLEANS	A.S. of N. Orleans	Last Wed.	8:00	Sept.-May	Cunningham Obs.	Dr. J. Adair Lyon, 1210 Broadway
NEW YORK	*A.A.A.	1st, 3rd Wed.	8:15	Oct.-May	Amer. Mus. Nat. Hist.	G. V. Plachy, Hayden Plan., *EN.* 2-8500
"	Junior Ast. Club	1st, 3rd Fri.	8:00	Oct.-May	Amer. Mus. Nat. Hist.	J. B. Rothschild, Hayden Plan., *EN.* 2-8500
NORFOLK, VA.	A.A.S. of Norfolk	2nd Thu.	8:00	All year	635 W. 29th St.	P. N. Anderson, 635 W. 29th St.
NORWALK, CAL.	Excelsior Tel. Club	Thu.	7:00	All year	Excelsior Union H. S.	Geo. F. Joyner, 410 Sproul St.
NORWALK, CONN.	Norwalk Ast. Soc.	Last Fri.	8:00	Sept.-June	Private houses	Mrs. A. Hamilton, 4 Union Pk., 6-5947
OAKLAND, CAL.	Eastbay A.A.	1st Sat.	8:00	Sept.-June	Chabot Obs.	Miss H. E. Neall, 6557 Whitney St.
OWENSBORO, KY.	*Owensboro A. C.	3rd Sat.	8:00	All year	Public Library	Fred Rutley, 129 W. 19th St.
PHILADELPHIA	A.A. of F.I.	3rd Fri.	8:00	All year	The Franklin Inst.	Edwin F. Bailey, *Rit.* 3050
"	*Rittenhouse A.S.	2nd Fri.	8:00	Oct.-May	The Franklin Inst.	A. C. Schock, *Rit.* 3050
PITTSBURGH	*A.A.A. of P'burgh	2nd Fri.	8:00	Sept.-June	Buhl Planetarium	Louis E. Bier, 837 Estella St.
PONTIAC, MICH.	*Pontiac A.A.A.	2nd Thu.	8:00	All year	Private homes	Harvey E. Orser, 34 Pine St.
PORTLAND, ME.	A.S. of Maine	2nd Fri.	8:00	All year	Private homes	H. M. Harris, 27 Victory Ave., S. Portland
PORTLAND, ORE.	*Ast. Study Group	1st Tue.	8:00	All year	309 Public Serv. Bldg.	H. J. Carruthers, 427 S. E. 61 Ave.
PROVIDENCE, R.I.	Skyscrapers, Inc.	Mon. or Wed.	8:00	All year	Ladd Observatory	Ladd Obs., Brown U., *GA.* 1633
RENO, NEV.	A.S. of Nev.	4th Wed.	8:00	All year	Univ. of Nevada	G. B. Blair, University of Nevada
ROCHESTER, N. Y.	Roch. Ast. Club	Alt. Fri.	8:00	Oct.-May	Univ. of Rochester	M. L. Groff, 400 University Ave.
SACRAMENTO	Sac. Val. A. S.	. . .	8:00	All year	Sacramento College	S. J. Smyth, 246 41st St.
SAN DIEGO, CAL.	Ast. Soc. of S. D.	1st Fri.	7:30	Oct.-June	504 Elec. Bldg.	R. M. Lippert, Box 41, N. Park Sta.
SCHENECTADY	S'tady Ast. Club	Meetings suspended				C. H. Chapman, 216 Glen Ave., Scotia
SOUTH BEND, IND.	St. Joseph Val. Ast.	Last Tue.	8:00	All year	928 Oak St.	F. K. Czyzewski, South Bend Tribune
TACOMA, WASH.	Tacoma A.A.	Meetings suspended				Grant Burke, Route 3, Box 349
TULSA, OKLA.	Tulsa A.S.	Occasional meetings				V. L. Jones, 4-8462
WASHINGTON, D.C.	Nat'l. Cap. A.A.A.	1st Sat.	8:00	Oct.-June	U. S. Nat'l. Museum	Mrs. Wm. Harris, 4315 Chesapeake, N.W.
WICHITA, KANS.	*Wichita A.S.	2nd Tue.	8:00	All year	E. High Sch., Rm. 214	S. S. Whitehead, 2322 E. Douglas, 33148
WORCESTER, Mass.	*Aldrich Ast. Club	2nd Tue.	7:30	All year	Mus. Natural History	W. C. Lovell, 158 Austin, 31559
YAKIMA, WASH.	Yak. Am. Astr'mers	3rd Tue.	7:30	All year	Chamb. of Comm. Bldg.	C. A. Zumwalt, 1019 Pleasant

†June, Jul., Aug., City parks ††Dinner meeting †††Nearest 1st-quarter moon

DEEP-SKY WONDERS

AMONG marvels for observation in October skies are the objects listed here, some of which are not shown on the chart. The informal descriptions are for common telescopes. Norton designations are in parentheses.

Sagittarius. M75, $20^h\ 2^m.9$, —22° 04′; small, faint globular. It resembles a hazy star when seen through a 3-inch telescope.

Aquarius. M72, $20^h\ 50^m.5$, —12° 45′; small, dim globular, like a fuzzy ball.

Lacerta. NGC 7243 (75^8), $22^h\ 11^m.3$, +49° 23′; cluster of 40 stars, on the edge of the Milky Way.

Pisces. M74, $1^h\ 34^m$, +15° 32′; very dim spiral. Compare it with its great neighbors, M33 and M31.

Andromeda. NGC 891 (19^5), $2^h\ 19^m.3$, +42° 07′; very faint spiral. In a large amateur telescope it appears somewhat club-shaped.

L. S. COPELAND

STARS FOR OCTOBER

from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., standard time, on the 7th and 23rd of the month, respectively. The 40° north horizon is a solid circle; the others are circles, too, but dashed in part. When facing north, hold "North" at the bottom, and similarly for other directions. This is a stereographic projection, in which the flattened appearance of the sky itself is closely reproduced, without distortion.

In 1663 when he was only 24, James Gregory,* Scottish mathematician and astronomer, published his treatise *Optica Promota*, an optically accurate account of mirrors and lenses beginning with the re-discovery of the sine-law of Snellius and Descartes which Gregory supported first by mathematical argument and next by careful experiments, followed by an account of a reflecting telescope.

But, he had no means of constructing such an instrument.

In London where he went in hopes of finding an optician capable of making his telescope, Gregory met Collins and Hooke who put him in touch with a celebrated craftsman, Reive. An attempt was made but the resulting mirrors were a failure and the project was abandoned. Later, Hooke succeeded and in 1674 presented the first Gregorian telescope to the Royal Society.

If Gregory had been looking for someone to construct his telescope *today*, he might well have taken his project to Perkin-Elmer. For it has been the privilege of Perkin-Elmer to collaborate in the invention, construction, and improvement of many optical instruments and elements. Perkin-Elmer scientists and engineers have been working successfully with leaders of Industry, Education, and the Armed Forces to make possible the mass production of instruments of even greater accuracy for war-time and *post-war* industrial analysis, control, inspection, and observation.

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Custom-built optical instruments for industrial analysis, control and inspection.

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